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RAIN AND RIVERS.

LONDON
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NEW-STREET SQUARE.

RAIN AND RIVERS

OR

HUTTON AND PLAYFAIR

AGAINST

LYELL AND ALL COMERS.

BY COLONEL GEORGE GREENWOOD.

Multa renascentur quæ jam cecidere, cadentque
Quæ nunc sunt in honore.

THIRD EDITION.

LONDON:
LONGMANS, GREEN, AND CO.
1876.

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188. e. 66.

PREFACE

TO

THE SECOND EDITION.

I PREFACE the Second Edition with this letter, which appeared in the Athenæum, February 17, 1866 :—

Rain and Rivers.—In the *Journal of the Geological Society*, published in November, 1865, Messrs. Foster and Topley, of the Government Geological Survey, attribute the denudation of the Weald *Hill* to 'Rain and Rivers.' More than this, there appears to be a strong tendency to the 'Rain and River' theory among the young practical geologists of the Government Survey (who have no theories of their own to defend), whether in England, Ireland, Scotland, Canada, Australia, or India. So far so good. Great A is accomplished; but there is still a great B to be learnt. The great B is, that man and mammalia, that is, the most perfect creatures, may have existed on the land from the beginning, and *before* the first strata were formed in the sea, and consequently that Darwinism and the 'development' theory are myths. The entire surface of the earth is covered with soil. That soil is rotted subsoil. Owing to atmospheric disintegration, soil is in constant formation over the entire surface of the earth. Owing to the erosion of 'Rain and Rivers,' that soil is in constant movement down the hill-side to the valley, and along the valley to the sea. The land, then, is the region of perpetual disintegration, denudation, and destruction. The sea is the region of perpetual deposit and conservation. And sea strata, when hoisted up by heat in the form of slate, sandstone, limestone, &c., form museums of sea life of an antiquity quite incomprehensible to man. But these museums contain sea life only; land animals neither live nor die in the sea; they live and die on the land. And where are the museums for the preservation of ancient land life? There cannot be such a thing. The

entire surface of the earth is perpetually vanishing, and with it the museums for the preservation of ancient land life. The most ancient museums of land life are caverns, filled-up lakes, bogs, and drift and alluvium—things which, speaking geologically, were formed yesterday, and will be gone to-morrow. In these modern land museums, however, the remains of man and extinct mammalia are found, and they *would* be found in more ancient land museums, if such ancient land museums *could* exist. In the *Geological Magazine* of January last, page 2, the editor tells us that, 'Foraminifera of the present day form no less than 95 per cent. of the ooze covering the *floor* of the wide Atlantic ocean.' Suppose our present continents to be destroyed or submerged,—

> And where the Atlantic rolls wide continents *shall bloom*;

—that is, suppose that this 'floor of the wide Atlantic ocean,' turned into slate, shall be raised up as the Silurian slates have been: is the geologist of after ages to dub one of these Foraminifera the *Eozoon Atlanticon*, and to inform his pupils that it was almost the sole existent animal of the *period when* that deposit was formed, instead of the *place where* that deposit was formed? That is, that from the beginning of the world up to the 19th century inclusive, Foraminifera were the dominant race on this terraqueous globe? Yet this is the argument of our present geologists as regards the Eozoon Canadense, the Oldhamia Antiqua, and the Silurian Trilobites. In land-drifts the remains of no sea-fish or sea shells are found. Are we to argue from this that there were no fish or shellfish in the sea during the *period* when these land-drifts were formed? The whole affair is the result of the most childish confusion between space and time, between place and period. That is, because in the deposit of a certain *place* such a life only existed, we set it down that in the *period* when that deposit was formed that life only existed. Hence such errors as 'The age of reptiles,' 'The diluvial period,' 'The boulder period,' 'The drift period,' 'The period of invertebrates,' 'The pluvial period,' 'The gravel period,' 'The peat period,' 'The terrace era,' &c.

GEORGE GREENWOOD, Colonel.

BROOKWOOD PARK, ALRESFORD:
Feb. 2, 1866.

The doctrines advocated in this book were first published by me in the second edition of the 'Tree-lifter,' Pt. III., 1853, before I had ever heard of Hutton. Then in the first edition of 'Rain and Rivers,' 1857. In 1863 Mr. Jukes writes, 'This chapter had been sent to the printers some time before I became acquainted with an excellent little work called "Rain and Rivers," published in 1857 by Colonel George Greenwood, in which the atmospheric origin of all river valleys is advocated in the clearest and most convincing style. I would beg leave to recommend it to the perusal of all geologists.'—*School Manual of Geology.*

The 'Rain and River' theory lays the first foundation stone of Geology, because it shows the origin of stratification; and it lays the first foundation stone of Physical Geography, because it shows the difference between a hill and a valley. See denudation of the Weald *Hill.*

PREFACE

TO

THE THIRD EDITION.

A memorandum left by my late uncle has imposed upon me the grateful task of republishing his works —'Rain and Rivers,' 'The Tree-Lifter,' and 'Hints on Horsemanship.' The materials for the present edition of 'Rain and Rivers' had been from time to time collected by Colonel Greenwood with all his characteristic energy, during the interval between the publication of the Second Edition in 1866 and his death in November, 1875. During the same period he was contributing to various periodicals numerous papers and letters which are very useful in illustration of the views on subaerial denudation which he so constantly and zealously advocated. These letters, etc., are now in course of publication in a collected form, with a short memoir of their indefatigable author prefixed.

CHARLES W. GREENWOOD.

42, WALTON STREET, HANS PLACE :
May, 1876.

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* This engraving has been most obligingly lent for the illustration of this subject by Viscount Milton and Dr. W. B. Cheadle. It is one of the numerous illustrations to their interesting work, entitled "The North-West Passage by Land. Being a Narrative of an Expedition from the Atlantic to the Pacific," 8vo. London, 1865. Published by Messrs. Cassell, Petter, and Galpin.

RAIN AND RIVERS.

CHAPTER I.

LYELL'S FOUR CONTRADICTORY THEORIES OF FORMING VALLEYS.

LYELL HAS RETROGRADED FROM SOUND TO UNSOUND DOCTRINES. LYELL'S OWN PARTICULAR THEORY OF THE FORMATION OF VALLEYS. ORIGIN OF ALLUVIAL PLAINS. VALLEYS FORMED ACCORDING TO LYELL'S THEORIES *SHOULD BE* BARE OF SOIL. VALLEYS *ARE* RICH IN SOIL. ACCUMULATION OF MAN'S SUBSISTENCE, AND THEREFORE HIS EXISTENCE, GREATLY DEPENDENT ON ACCUMULATION OF SOIL.

Lyell has retrograded from sound to unsound doctrines.

LYELL writes of Werner: 'When sound opinions had thus for twenty years (fifty centuries) prevailed in Europe (the world), ... Werner (Lyell), by his simple dictum, caused a retrograde movement, and not only overturned the true theory, but substituted for it one of the most unphilosophical that can be well imagined.'

In reference to the theory that valleys are formed by 'rain and rivers,' these words of Lyell are true

of himself as I have altered them. There is, perhaps, no creed of man which, like this, can be traced up to the most remote antiquity, and traced down from the most remote antiquity to the present day. Lyell has himself quoted Pythagoras for it, through the medium of Ovid:

> Eluvie mons est deductus in æquor.
> Quodque fuit campus *vallem decursus aquarum*
> Fecit.

But Pythagoras only enunciates the doctrine of Eastern antiquity: that is, of the Egyptians, the Chaldæans, the Hindoos, and Chinese. But since Pythagoras introduced this doctrine in the West, if it has ever slumbered, it has been perpetually *re*-originated. Lyell shows that among the Greeks it was taught by Aristotle; among the Romans by Strabo; among the Saracens by Avicenna; in Italy by Moro, Generelli, and Targioni; and in England by Ray, Hutton, and Playfair. To this list I may add the revered name of Sir Henry de la Beche. Rage 449, Report on Devon and Cornwall, he gives a disquisition headed 'Effects of Atmospheric Influences,' and 'Transport of Detritus by Rivers,' the doctrines of which are precisely those of 'Rain and Rivers.' I believe, also, that Kant preached these doctrines in Germany.*

* I think that even Confucius, but certainly that Plutarch, might be inserted in the list. In modern times also the doctrine is most admirably advocated in Dr. Arnott's 'Elements of Physics' and in Powlett Scrope's 'Geology of Central France.'

Lyell's own particular theory of the formation of valleys.

In contradiction, however, to these authorities, ancient and modern—in contradiction, as I think, to common sense, and in contradiction to three other theories which he himself uses—Lyell has started *a theory of his own* in reference to the formation of valleys. He conceives that as land has been slowly raised through the sea and above it by subterranean heat, the waves and currents of the sea have formed the valleys.

In the second edition of the 'Tree-lifter,' I answered, 'That the action of *waves* on land slowly emerging from the deep should have a tendency to wash away soft parts and to leave hard parts, I can conceive; but to attribute the formation of our valleys to this cause, is to suppose that the materials of all the valleys running from the tops of all the heights on the globe were originally softer than the materials of the intervening ridges; but in almost all cases we can *see* that this is not so, by the corresponding strata on the opposite sides of valleys.'

In regard to *currents:* a current might decapitate a continent as it rose, supposing equal softness of materials, or it might scoop a horizontal groove of any size or depth, or (granting lines of hard intervening ridges) many grooves. But they must all be horizontal, and *in one direction.* No marine current could make a single channel *sloping from a height* to the sea; still less the myriads on myriads

of dry upper valleys which ramify *in all directions*, from all river valleys, through and to all sides of the tops of all elevations, whether high or low.

Origin of alluvial plains.

The sea *ends* every valley, but it never yet *began* one. That is, when the river has done its utmost it is the sea which *prevents* the farther deepening of the valley. But, as the denudation and deepening of the inclined upper parts continue, the lower part of the valley becomes horizontal. The passage of the detritus of the upper parts is then checked in this horizonal part, and soil accumulates there *backward up* the valley. This is the origin of alluvial plains, which I have never seen an attempt to account for. They seem, by common consent, to be *omitted* in all theories of the formation of valleys. Alluvial plains are, however, frequent features over the globe, and most important features. Yet neither the formation of any of them, nor the present and perpetual daily growth of each of them, can be accounted for, except by the principles which I advocate. And, instead of the sea forming valleys in the land, valleys often form land in the sea, that is, deltas; and as the sea, by checking the longitudinal rush of rivers, allows this deposit of land *forward* in it, the sea may thus be said to assist in *prolonging* valleys.

'Bottle off the sea,' and all estuaries and their valleys will be deepened; for the tidal part of each river will be a torrent on the brow of a mountain.

In this case deltas and alluviums would disappear; but they would not 'go with a run,' or by the *direct* action of rivers. Rivers would only cut ravines through them *backward* from the sea; the rest must wait for disintegration and the wash of rain, and would vanish in the form of two parallel terraces. The sea *begins* the deltas and alluviums and *preserves* them now. And in this sense the sea may be said to *fill valleys in*, instead of *scooping them out*. This subject will be treated in the last chapter.

But besides this *No.* 1 theory of his own, which I shall call the *submarine theory*, Lyell freely adopts three other theories, each of them contradictory to his own theory, and each contradictory to the other. *No.* 2, a theory of Mr. Hopkins's, that valleys are cracks formed in the igneous elevation of the land, and Lyell says that Mr. Hopkins accounts for these 'by mathematical methods.' I shall call this the igneous mathematical theory. *No.* 3, the erosion of their banks by rivers, the erosion theory; and *No.* 4, the subaerial denudation from disintegration and the wash of rain, the subaerial theory. All these four theories Lyell uses, sometimes each as if it was his only theory, and always each as if it were consistent with the other three. Indeed, I think I shall show that a *fifth* and a *sixth* theory for the formation of valleys may fairly be placed to Lyell's credit (or discredit ?).

Let us try if one theory will not suffice: the last

of the four, the subaerial theory; and if, in supporting this theory against the three first, arguments are sometimes used against all three generally, and sometimes the fight is shifted *abruptly* from one particular theory to the other, the blame must not be laid on the writer of this.

Valleys formed according to three out of four of Lyell's theories *should be* bare of soil.

If either of the first three theories were true; if valleys were formed by submarine denudation, either by waves or currents; or if they were formed by 'mathematical earthquakes,' or by the erosion of their banks by rivers—in all these cases valleys *ought to be* more bare of soil than any other parts of the earth. But they *are* more rich in soil than any other parts of the earth.

Valleys are rich in soil.

Soil is simply rotten subsoil (mixed with vegetable remains). But there are particular spaces so steep (precipices) that even gravity or wind, independent of the wash of rain, would never suffer a grain of soil to remain on them for an instant. Soil is not the less in perpetual formation on these spaces. The faces of precipices and bare rocks rot, and thus soil is in perpetual formation over the whole surface of the earth. And from the whole surface of the earth it is in perpetual movement, by the wash of rain, to the bottom of the sea. This travelling rotten part of the earth is the only part which supports vegetable existence, and consequently animal existence.

The reason why valleys are richer in soil than

other parts of the earth is that they are the roads by which soil travels to the sea. And the same cause which has excavated valleys, and which still denudes them—rain—also deposits in them. And valleys always hold soil as rivers always hold water, though the soil and the water are both *in transitu*. Directly as each valley lengthens, its longitudinal slope becomes gentle. Directly as it widens, its lateral slope becomes gentle. And directly as the gentleness of the slope of each valley is the accumulation of soil. For as rain takes the soil from the hill-top down the valley to the sea, in proportion to the flatness of the valley will deposit of soil exceed denudation. Man's subsistence, and therefore his existence, depend very much on these vast accumulations of soil. And therefore (I was going to say) it is of infinite consequence to man to know the principles on which depend the formation, accumulation, and denudation of soil. But man—'poor hungry sinner'—does not wait for his dinner till he is shown where to get it by a scientific theory. He finds by *practice* where he can grow the crops which support him and his domestic animals. There are, however, infinite myriads of cases where denudation of soil may be retarded by man, and where accumulation of soil may be facilitated by him, if the true principles on which these depend are understood. And so far the knowledge of these principles may be said to be of consequence to us all, quicunque terræ munere

Accumulation of man's subsistence and therefore man's existence, greatly dependent on accumulation of soil.

vescimur, from the labourer to the throne, sive reges sive inopes erimus coloni.

But besides our *food*, besides producing and supporting the vegetable crops and animals most valuable to man, alluvial deposits are the magazines of the minerals most valued by man. Platina, gold (5,500*l.* worth has been *picked up* in one nugget), tin, diamonds, and precious stones are sifted, sorted, and stored by Nature in these beds, during her universal operations of disintegration, denudation, and deposit. The subject, also, is of vital importance—the very foundation-stone—in theories of geology and physical geography; also in engineering questions touching harbours and docks, drainage and irrigation, the embanking of alluvial rivers, the reclaiming of land from the sea or marshes (works which place in daily jeopardy millions of lives), and the sewage and supply of water to 'the cities of the plain.' And last, and oh, ye gold-finders and utilitarians, not least,

> the boundless store
> Of charms which nature to her votary yields,

the subject explains the origin even of these. The alteration of the ravine and ridge, the hill and dale, the exquisite beauty of the earth's *surface*—of all that we *see* of the earth—the 'dread magnificence' of the Alpine chasm, and the rich loveliness of the alluvial vale, are the everchanging products resulting from (start not at the bathos) the daily '*wash of rain.*'

In addition, therefore, to what I published in the second edition of the 'Tree-lifter,' I shall devote this treatise to what I conceive to be the errors of Lyell on this important subject. For I think that I can show that this illustrious writer is here not only contradictory to what we see in nature, but *completely contradictory to himself throughout.*

CHAPTER II.

TERRACES OF GLEN ROY AND LAKES OF AUVERGNE.

TERRACES OF GLEN ROY PROVE ENORMOUS DENUDATION IN FORMER TIMES. WHY SHOULD THIS DENUDATION HAVE CEASED NOW? SCOTTISH KAMES. TERRACES OF THE FRASER RIVER, GORGE OF THE HUMBER, AND THE PLAIN OF YORK. TERRACES OF THE HIMALAYA. LAKES OF AUVERGNE FIRST FILLED WITH ALLUVIUM, THEN CUT INTO HILLS AND VALLEYS BY RAIN AND RIVERS. THIS IS CONTRARY TO THE SUBMARINE AND IN FAVOUR OF THE SUBAERIAL THEORY. WHY VALLEYS GROW WIDER AS THEY DESCEND. A LAKE, LIKE A VALLEY, CAN ONLY HAVE ONE OUTLET. SOURCE OF THE NILE OR OF ANY RIVER. HILLS AND VALLEYS OF VOLCANIC DISTRICT OF CENTRAL FRANCE CONTRARY TO SUBMARINE AND IN FAVOUR OF THE SUBAERIAL THEORY. COMPARATIVE ETERNITY OF CONES OWING TO THEIR SHAPE. CLIFFS ON THE SEINE NOT MARINE.

I WILL again begin the chapter by applying Lyell's own words to himself: 'A false theory, it is well known, may render us blind to the facts which are opposed to our prepossessions, or may conceal from us their true import when we behold them.' In reference to Lyell's own *submarine theory* of forming valleys, I had intended to extract from the beginning of his 'Elements,' 2nd edition, to the end of his 'Principles,' 7th edition, all passages contradicting that theory in particular, or each other generally. I found that I became *far too voluminous.*

For the questions of denudation in the formation of valleys, and of deposit in the formation of *all strata*, alluviums, and drift-beds, are of such a universal and constant occurrence and recurrence in geology that there is scarcely a page in Lyell's works in which he will not be found an unwilling and *unintentional* witness against his own submarine theory, and in favour of the *common-sense* plan of forming valleys by 'rain and rivers.' But though I have

Parallel Roads of Glen Roy.

thus been obliged to curtail my extracts, I have still retained my original order of operations.

Terraces of Glen Roy prove enormous denudation in former times.

In reference to the formation of the parallel terraces of Glen Roy, Lyell ('Elements,' chap. vii.) concurs in these words with 'Dr. M'Culloch, Sir T. D. Lauder, Mr. Darwin, and Mr. Agassiz. There is one point, however, on which all are agreed, namely, that these shelves are ancient beaches, or littoral formations, accumulated round the edges of one or more sheets of water, which once stood at the level, first of the highest shelf, and successively at the

height of the two others. *It is well known that wherever a lake or fiord exists surrounded by steep mountains, subject to disintegration by frost or the action of torrents, some loose matter is washed down annually, especially during the melting of snow*, and a check is given to the descent of the detritus at the point where it reaches the waters of the lake.'

Now here is a denudation not *longitudinal*, or, as Lyell has just said, from 'the action of torrents,' or, as Professor Sedgwick would say, 'acting on lines,' but *lateral*. It is a denudation of an enormous breadth of hill-*side*. For, as Lyell says, these terraces extend 'over a space of many leagues in length,' and 'they are from ten to sixty feet broad.'

And it is not, as Lyell has said, that 'a check is given to the descent of the detritus at the point where it reaches the waters of the lake,' but that all denudation ceases there. Subaqueous regions are indeed the regions of *deposit*, as subaerial regions are the regions of *denudation*. But deposit takes place at the bottom, not at the top of the water; and these terraces are not formed by the accumulation of deposit, but by the absence of denudation compared with the parts above them. The 'detritus' from the denudation, instead of being arrested 'at the point where it reached the waters of the lake,' went to the bottom of the lake, and has long since been cleared *out* of the valley by the same power which brought it *in* to the valley—rain.

If these philosophers are all agreed (and who will disagree with them?) that this enormous denudation of the hill sides and tops took place in former days, should they not give us some reason why it should have ceased in these days?

Why should this denudation have ceased now?

This was so printed in 1857, but since that time the once sane Lyell has gone into all the insanities* of glacialism. He now asserts:

Arduis
Pronos relabi posse rivos
Montibus, et Tiberim reverti.

He now builds up 'ice-dams,' to turn the water back the wrong way, over the water-partings or so-called *cols!* And since that time I have had the pleasure, on the 18th September, 1863, to walk up Glen Roy, and I published the following in the Athenæum. 'I think that these terraces are *not* the remains of shores of any kind, either sea-shores or lake-shores. They are the remains of '*patches* of alluvial plains.' Years ago ('Rain and Rivers,' pages 4 and 227 of

* I have been reproached for the use of this word in the 2nd edition. Let the reader judge. Agassiz (Edinburgh Phil. Jour.) says: 'A crust of ice covered the superficies of the earth, and enveloped in its rigid mantle the remains of organisms which but a moment before had been enjoying existence on its surface. In a word, a period appeared in which the greater portion of the earth was covered with a mass of frozen water, a period in which all life was annihilated, everything organic was put an end to—the Glacial Period.' Again, in his account of his travels in Brazil, published in 1868, he tells us that the valley of the Amazon, perhaps 4000 miles long, with all its affluents, was one glacier, ending *at the level of the sea under the equator.* Would it be more insane to tell us that the sun was a snow-ball?

this edition) I described at length the birth, life, and death of these transitory alluvial plains. But I was not till now aware of their disposition to set up their own gravestones. Shortly, these alluvial patches come and go thus. Every barrier of *hard* rock which crosses the bed of a river or valley becomes a negative key to the depth of the river and valley above the barrier. Thus deep shalt thou go and no deeper. But as denudation is ever at work, the bed of the river and of the *soft* valley above the barrier becomes horizontal at the same level as the barrier. The flood waters are checked at the barrier, overflow the horizontal plain, and form an alluvial patch. The barrier sinks and is widened from erosion. The alluvial patch is no longer overflowed. The river is confined between walls of its own building. It sets to work to tear them down. It carries off the alluvial patch which it had deposited till it leaves only two terraces against the hill-sides. Countless ages may elapse while these vast alluviums are vanishing by the erosion of rain. And during that time that part of the hill-side on which they rest is protected from denudation, while the part above is exposed to denudation. So that, after the alluvial terrace has entirely vanished, a terrace of the natural rock remains. This may continue *visible* for countless ages more. I think that this is the case in many parts of the upper terraces of Glen Roy, and possibly in the upper terrace of the Fraser River, shown in the cut from Lord Milton's

work. Having cleared a horizontal plain below the level of these terraces and at the new level of the barrier, the river again floods over and begins a new alluvial patch below the two parallel terraces. We only want eyes to see that parallel terraces are being formed in this way, at this instant, along the beds of Glen Roy and Glen Spean, and these recent terraces are composed of the same materials as the ancient ones. In Lyell's elements two of these lower terraces by the river-side are actually delineated. But I was thoroughly astonished at the *multiplicity* of terraces with which the hill-sides are scored. From Sir T. Dick Lauder's drawing, and Mr. Jamieson's map, given in Lyell's 'Antiquity of Man,' one would suppose that there were at most three terraces. So that one must imagine the valley to have been emptied of water or hollowed out of the land at three swoops—at a hop, a step, and a jump. Whereas the name of the terraces is legion. Looking from the inn door at Roy-bridge on your right, is a very broad terrace on which stands the farm of Achderrig. Follow the road towards Bohinnie along the side of this terrace; you will find it cut into several minor terraces, each with its corresponding terrace on the other side of the valley. As you walk up Glen Roy you are always accompanied by from five to ten terraces, ever beginning, ever-ceasing. They are in every stage of existence and of vanishment. In some places it may happen that on

one side of the valley the terrace is only faintly delineated, or perhaps obliterated, while on the opposite side there is a large patch of alluvial plain still left. That no writer should have mentioned the *multiplicity* of these terraces, is to me wholly unaccountable. For it is the 'open sesame' of the secret of the formation of the terraces, besides showing the extreme *gradualness* of the erosion and formation of the valley. If anyone wishes to see the causes which formed our valleys still hard at their work, let him visit Glen Roy and Glen Spean. I do not doubt that terraced alluvial patches are very general affairs, and that indications of them, more or less clear, will be found in all river valleys which have rapids or gorges.

Terraces of the Fraser River.

So published in the two first editions. Lord Milton and Dr. Cheadle, in their 'North-West Passage by Land,' tell us of the parallel terraces of the Fraser, Thompson, Athabasca, Kootanie, Columbia, the rivers of California and Mexico, and wind up thus: 'It is worthy of remark that in nearly every instance where these terraces have been found in various countries they occur in *three* successive tiers, as in those of British Columbia, which would seem to mark as many separate epochs when important geological disturbances took place.' Yet Lord Milton's own drawing of these terraces gives four terraces instead of three! That the fourth or lowest terrace bordering the river is a 'river haugh,' and is formed

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THE FOUR TERRACES ON THE FRASER RIVER

by the overflow and deposit of the river, no one will dispute, and, if so, why not the terrace above it or the three terraces above it? The two conical mountains which

> Like giants stand
> To sentinel enchanted land,

mark where the narrow gorge begins below the wide alluvial flat. But the whole of these conical mountains, on which the remains of the terraces rest, exist only as the remains of the beds which have formerly surrounded them; and, as I have said of the Weald Hill and the North and South Downs—those all-powerful chemists and excavators, air and moisture, rain and rivers, have as much *formed* these cones as the sculptor has formed the statue out of the Parian or Carrara block. And the human and the natural operators have worked on the same principle—that is, by the abstraction of external parts; and these cones stand out a magnificent monument of the enormous masses which have vanished by the disintegration of the atmosphere and the erosion of rain and rivers. These cones, however, though the *monument*, are by no means the *measure* of this denudation, since they have themselves been melting away for 'an eternity of time,' and are day by day vanishing *tenues in auras* at this instant. All this is going on now all over the world and all day long. These simple yet sublime truths are beneath the contempt of poor marvel-mongering human nature. We must have a

cataclysm, or a glacial epoch, or a wave of translation, or a diluvial period, or a boulder period, or a drift period, or a gravel period to account for every heap of rain-wash.

Any one may make 'parallel terraces' for himself in the road-side gutter. Dam the run of rain; a pool will form above the dam. Every rain will deposit on the bed of the pool, till the flat alluvium rises to the height of the dam. Take away the dam. The run of rain cuts through the alluvium which it has deposited, and runs between two parallel terraces till they vanish by denudation. This is the whole secret of the terraces of Glen Roy, or of any other valley or river. Neither 'ice-dam,' nor 'glacial epoch,' nor sea-shore, nor lake is required. Dr. Adams found such deposits at the second cataracts of the Nile, 130 feet above its present bed. The principle of the formation of the bluffs of the Mississippi, the loess of the Rhine and Danube, &c., may be exactly shown in the way-side puddle.

In chalk valleys the material of which is of uniform softness, single terraces, that is, on one side of the valley only, may be formed by the river eroding the soft side of its channel, deepening the valley, and leaving its gravel bed as a terrace. So that any number of long lines of gravel terraces, which were the beds of rivers, or even the beds of rain valleys, may be deposited on the sides of valleys, first on one side of the valley, then on the opposite side. Parallel terraces,

that is, one on each side of the valley, may be ancient shores; but the vast majority are the remains of alluviums where no lakes have ever been. These patches result from alternations of hard and soft strata, and as sure as there are alternations of hard and soft strata in the course of a river or valley, so sure will there be alternations of gorge and alluvial flat. For all alluvial flats are formed by the stoppage of the lowering of the valley. The valley above the stoppage is then worn down horizontal. The rain flood waters from the sides and inclined parts of the valley, checked at the flat plains, overflow and deposit alluvium. The sea stops the lowering of every valley, therefore the bed of every valley is flat and alluvial at the end next the sea. But besides this marine or main alluvial plain, a valley may have any number of what I have called *patches* of alluvial plain at any distance from the sea. These patches occur above every hard stratum which crosses the course of the valley or river, and which stops for a time the lowering of the valley or river bed. The 'Kames' of Carstairs result from this. The hard beds of the Clyde and Mouse Water at Lanark were once as high and higher than the top of Cartland Crags. This allowed the formation of enormous patches of alluvial plains above Lanark and Carstairs. As the hard gorges of the Clyde and Cartland Crags have been lowered the alluviums have been cut through, and are vanishing in the form of parallel terraces and 'Kames.' There are ancient ter-

Scottish Kames.

races and alluviums recent and in actual formation in the long and beautiful gorges of the lower Mouse Water whenever an interval of soft strata occurs in the banks of these gorges. One may be seen from the road and bridge immediately above the magnificent gorge through Cartland Crags. Another immediately above the almost equally magnificent gorge beginning at Cleghorn Bridge. Man has run his roads and has bridged the river at these two crossing places of nature. Below Cartland Crags vast alluviums have always (that is, for millions of years) existed above Stonebynes Falls, caused by the hardness of the rocks there. The remains of these alluviums are still to be seen on the hillside, like parallel terraces pictured by Lord Milton, and modern ones are still growing from the same cause. Indeed, the singularly hard Devonian conglomerate rocks at Stonebynes Falls still give the level to the bed of the Mouse Water through Cartland Crags. Above the falls of the Clyde at Bonnington the river becomes smooth and sluggish about Tullyford with new alluviums, and the banks are terraced with old alluviums of sand with pebbles. While where the railroad from Lanark to Douglas crosses the river the country is one wide sea of ancient terraced alluviums. These extend over the hills between Lanark and Carstairs (by Ravenstruther), so that the water-parting between the Clyde and the Mouse Water is formed by hills capped with these alluviums. Rain and rivers in

destroying these alluviums, which they have formerly formed, have cut and cross-cut them into every form of ridge and knoll. The Clyde, from Carstairs up to its source, is at the same work now which it has been at for millions of years. That is, it is still cutting through old and recent alluviums or 'haughs' of all ages and at all levels, and forming new ones, which it gives, as Aladdin did his lamp, in exchange for old ones. This may be *seen* from the railway at express pace. Mr. Geikie seems wantonly to introduce 'mystery' and marvel where in nature simplicity itself reigns. He turns a certain pool among these alluviums into 'the crater of a volcano like one of those in the Eifel.' Now the bed of this *volcanic* pool is formed of the most perfectly *water-worn* pebbles, and its sides of drifted sand, boulders, and pebbles—most remarkable materials for the construction of a volcanic crater!

Gorge of the Humber and the Plain of York.

The 'Plain of York,' immediately above the gorge of the Humber, results from the alternation of hard and soft strata. The hard oolites and chalk of the York Wolds on the north, and of the Lincolnshire heights and Lincolnshire wolds on the south, have formed the gorge of the Humber, which once flowed as high and higher than these heights. In the meantime, rain and the rivers have always excavated deep flat valleys in the soft Triassic strata west of these heights, and have deposited patches of alluvium in them, ever varying in height with the ever-varying

level of the bed of the Humber gorge. Thus has been formed 'the Plain of York.'

Terraces of the Himalaya.

In his description of the parallel terraces of the Himalaya, Dr. Hooker's *facts* exactly correspond with my theory, that from the alternation of hard and soft strata across valleys, an alternation of gorge and alluvial flat results: as each gorge sinks and widens, the alluvium above is cut into two parallel terraces. While on the Tambur river (vol. i.,* page 199), Dr. Hooker says: 'I was almost startled with the sudden change from a gloomy gorge to an open flat.' Page 191, he says: 'Above these gorges are enormous accumulations of rocks, especially at the confluence of *lateral valleys*, where they rest upon little flats like the river terraces of the Mywa.' Now these 'lateral valleys' (longitudinal as regards the stretch of the strata) are simply the consequence of the erosion of rain and rivers in the soft strata above or behind the hard gorges, as I first said of the lateral valleys in the Weald clay above or behind the gorges of the North and South Downs. In his description of the terraces of the Yangma valley (page 219, *ibid.*), Dr. Hooker begins with a gorge: 'The scenery was wild and very grand, our route lying through a narrow gorge choked with pine trees, down which the river roared in a furious tor-

* Himalayan Journals. Notes of a Naturalist in Bengal. The Sikkim and Nepal Himalayas. By Joseph Dalton Hooker, M.D.R.N., F.R.S., London, 1855. Published by John Murray.

rent.' 'The path was very bad; often up ladders and along planks lashed to the faces of precipices, and overhanging the torrent which it crossed several times by plank bridges.' Above this gorge, and above other 'contracted parts of the valley,' came his *supposed* ancient lake beds and the parallel terraces which he depicts, and of which he says (page 233): 'On the opposite flank of the valley were several terraces, of which the highest appeared to tally with the level I occupied, and *the lowest was raised very little above the river;* none were continuous for any distance, but the upper one in particular could be most conspicuously traced up and down the main valley, whilst on looking across the eastern valley a much higher but less distinctly marked one appeared on it.' (See woodcut, copied from Dr. Hooker's work). In fact, the terraces have nothing to do with lakes. They are all the remains of ancient alluvial plains, as we should call them, or of 'river haughs,' as the Scotch would call them; and 'the lowest very little above the river' is a river haugh now in actual formation from the yearly floods of the river, and from the waste and erosion of the terraces above it. And all these terraces are at this moment on their way to the alluviums below, to the delta of the Ganges, to the bay of Bengal, and to the Indian Ocean, under convoy of rain and rivers, as much as the run of every other hill-side is on its way to the valley below, and from the valley below to the

sea at the end of the valley. The terraces are for a time arrested by the hard gorges; but as the hard gorges go, the terraces go. So far Dr. Hooker's facts and *my* theories agree. At page 222, *ibid.*, Dr. Hooker tells us that, 'being familiar with *sea* ice and berg transport during my voyages in the south polar regions,' *his* theory is that semi-tropical

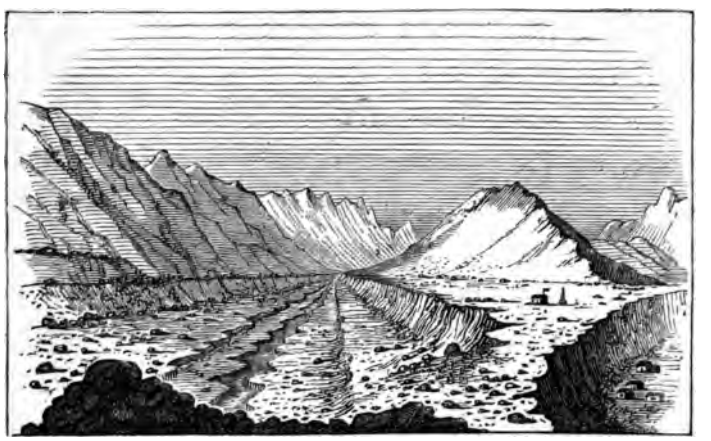


Diagram of the Glacial Terraces at the Fork of the Yangma Valley (copied, slightly reduced in size, from Dr. Hooker's Himalayan Journals, vol. i. p. 219).

Indian *land* must have been formed under a polar sea; and that once upon a time 'a glacial ocean stood high on the Himalaya, made fiords of the valleys, and floated bergs laden with blocks from the lateral gulleys, which the winds and currents would deposit along certain lines.'

Yet, if I wished for *facts* in favour of the *present* erosive powers of subaërial agents against that of *ancient* glacial sea, Dr. Hooker is the witness that I

should call. I might quote from almost every page of his journey to the Donkia Pass. Thus in vol. ii. page 41, he talks of 'the prevalence of land-slips, which descend sometimes 300 feet, carrying devastation along their course. They are caused by the melting of the snow-beds or by the action of the rains on the rocks. This phenomenon is as frequent and destructive as in Switzerland.' Again at page 76, 'Huge masses were ever and anon precipitated into the torrent with a roar that repeatedly spread consternation amongst us. During rains especially, and at night when the chilled atmospheric currents of air descended, and the sound was not dissipated as in the day time, the noise of these falls was sufficiently alarming. My tent was pitched near the base of the cliff and so high above the river that I had thought it beyond the reach of danger. But one morning I found a large fragment of granite had been hurled during the night to my very door; my dog having had a most narrow escape. I have seen few finer sights than the fall of these stupendous blocks into the furious torrent, along which they were carried amid feathery foam for many yards before settling.' Page 78, 'The rivers were much swollen, the size and number of the stones they rolled along, producing a deafening turmoil.' Page 97, 'We were suddenly startled from our repast by a noise like loud thunder, crash following crash, and echoing through the valley. The Phipun got up, and coolly said, 'The rocks are

falling: it is time we were off, it will rain soon.' The moist vapours had by this time so accumulated as to be condensed in rain on the cliffs of Chomiomo and Kinchinjhow, which loosened and precipitated avalanches of rocks and snow. We proceeded amidst dense fog, soon succeeded by rain, the roar of falling rocks on either hand increasing as these invisible giants spoke to one another in voices of thunder through the clouds. The effect was indescribably grand.' Page 112, 'Terrific land-slips had taken place along the valley, carrying down acres of rock, soil, and pine-forest into the stream, and I saw one which swept over 100 yards in breadth of forest. The bridge at the Tuktoong being carried away, we had to ascend 1000 feet to a place where the river could be crossed. In many places we had great difficulty in proceeding, the track being obliterated by the rains and landslips. Along the flats, now covered with a dense vegetation, we waded often knee deep in mud.' Page 125, 'Broad flats clothed with rhododendron, alternated with others covered with mud, boulders and débris which had flowed down the gorges on the west, and which still contained trees inclined in all directions, and buried up to their branches. Some of these débâcles were 400 yards across, and sloped at an angle of 2° to 3°, bearing on their surfaces blocks fifteen feet in diameter. They seem to subside materially, as I perceived they had left marks many feet higher on

the tree trunks. Such débâcles must often bury standing forests in a very favourable material, climate, and position for becoming fossilised. Page 126, 'Enormous masses of rocks were continually precipitated from the west side close to the shed in which I had taken up my quarters, keeping my people in constant alarm and causing a great commotion among the yaks, dogs, and ponies.' Page 127, 'Shoots of stones had descended from the ravines.' Page 128, 'Beyond this the path crossed the river and ascended rapidly over a mile of steeply sloping landslip, composed of angular fragments of granite, which were constantly falling from above and were extremely dangerous.' Page 153, 'The whole valley was buried under a torrent or débâcle of mud and boulders, and half a mile of its course was dammed up into a deep lake.' Page 154, 'I met my friend on the other side of the mud torrent.' Page 184, 'I descended obliquely down a very steep slope over upwards of a thousand feet of débris, the blocks on which were so loosely poised on one another that it was necessary to proceed with the utmost circumspection, for I was alone, and a false step would almost certainly have been followed by breaking a leg. The alternate freezing and thawing of rain amongst these masses must produce a constant downward motion on the whole pile of débris (which was upwards of 2000 feet high) and may account for the otherwise unexplained phenomenon

of continuous shoots of angular rocks reposing on very gentle slopes in other places.'

So far for the *present erosion* of rain and rivers. For the *present deposit* from them take Dr. Hooker's description of the Cosi (of which the Yangma is a tributary) where it runs out of the Himalaya and into the Ganges, page 86, vol. i., 'Even at this season (April, the end of the dry season) the enormous expanses of sand, the numerous shifting islets, and the long spits of mud, indicate the proximity of some very restless and resistless power. During the rains the scene must, indeed, be extraordinary when the Cosi lays many miles of land under water and pours so vast a quantity of detritus into the bed of the Ganges, that long islets are heaped up and swept away *in a few hours;* and the latter river becomes all but unnavigable. Boats are caught in whirlpools formed without a moment's warning, and sunk ere they have spun round thrice in the eddies.'

But from the above and from what follows, one would think that Lyell supposes denudation of hills only to go on in the neighbourhood of sheets of water and lakes, that is, 'wherever a lake or fiord exists;' and that, when the sheets of water have vanished, or the lakes have been filled up, the denudation ceases. For he describes ('Elements,' chapter xvi.) the filling up of the enormous ancient lakes of Auvergne by the denudation and deposit from the wash of rain. But he neglects to infer

Lake of Auvergne first filled with alluvium, then cut into hills and valleys by

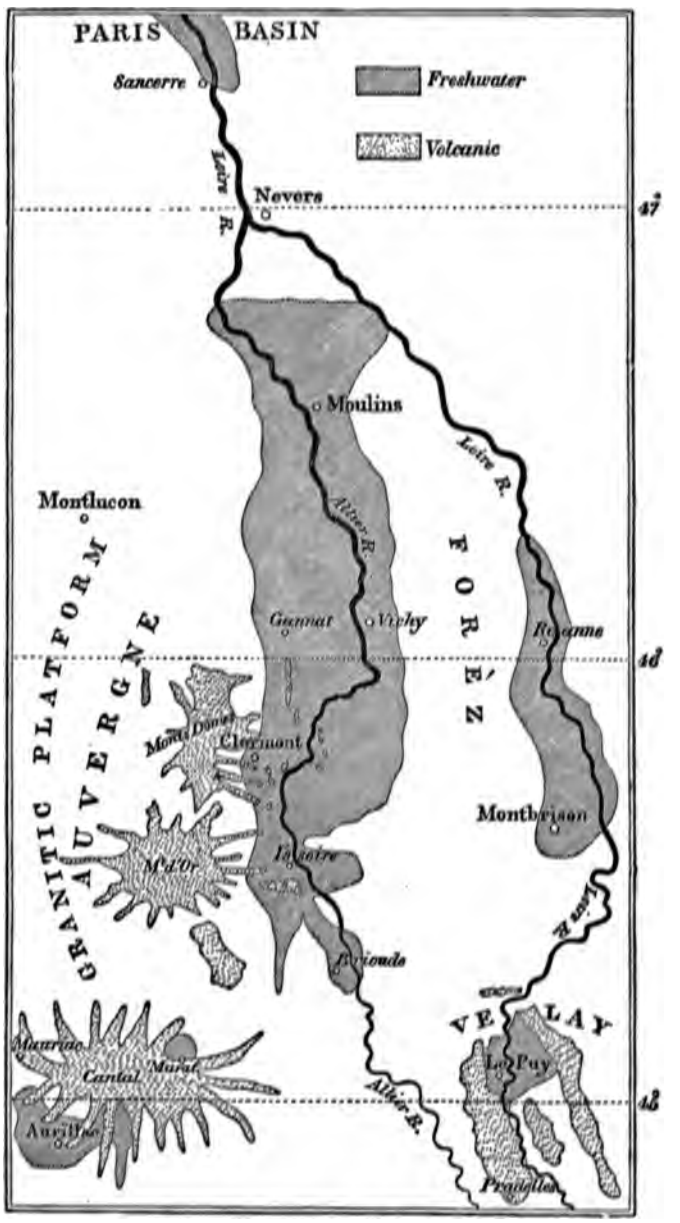
that the same denudation must *still* go on *there*, and deposit from that denudation *some*where; and that this denudation of land and deposit in water must pervade the entire terraqueous globe. rain and rivers.

Page 362, he writes: 'Before entering on any details, I may observe, that the study of this region, and of the others above alluded to, possesses a peculiar interest, very distinct in kind from that derivable from the investigation either of the Parisian or English tertiary strata.'

(*One* cause of 'peculiar interest' is, that the deposits have been *inland*; that is, by comparison, *on* land, and therefore contains the fossils of the *animals* which inhabited the *land*. This is referred to hereafter particularly in Chap. IV.)

'For we are presented in Auvergne with the evidence of a series of events of astonishing magnitude and grandeur, by which the original form and features of the country have been greatly changed, yet never so far obliterated but that they may still, in part at least, be restored in imagination. Great lakes have disappeared; lofty mountains have been formed by the reiterated emission of lava, preceded and followed by showers of sand and scoriæ; *deep valleys have been subsequently furrowed out through masses of lacustrine and volcanic origin.* At a still later date, new cones have been thrown up in these valleys; new lakes have been formed by the damming up of rivers, and *more than one creation of quadrupeds*,

birds, and plants have followed in succession; yet the region has preserved from first to last its geographical identity; and we can still recall to our thoughts its external condition and physical structure before these wonderful vicissitudes began, or while a part only of the whole had been completed. There was first a period when the spacious lakes, of which we still may trace the boundaries, lay at the foot of mountains of moderate elevation, unbroken by the bold peaks and precipices of Mont d'Or, and unadorned by the picturesque outline of the Puy de Dôme, or of the volcanic cones and craters now covering the granitic platform. During this earlier scene of repose, deltas were slowly formed; beds of marl and sand several hundred feet thick deposited; siliceous and calcareous rocks precipitated from the waters of mineral springs; shells and insects imbedded, together with the remains of the crocodile and tortoise, the eggs and bones of water-birds, and the skeletons of *quadrupeds*, some of them belonging to the same genera as those entombed in the gypsum of Paris. To this tranquil condition of the surface succeeded the era of volcanic eruptions, when the lakes were drained and when the fertility of the mountainous district was probably enhanced by the igneous matter ejected from below, and poured down upon the more sterile granite. During these changes which appear to have taken place in the miocene epoch, the *mastodon*, *rhinoceros*, *elephant*, *tapir*, *hippo-*


PARIS BASIN
Freshwater
Volcanic
Sancerre
Loire R.
Nevers
47°
Moulins
Loire R.
Montlucon
Allier R.
GRANITIC PLATFORM
AUVERGNE
FOREZ
Gannat
Vichy
Roanne
46°
Mont Dore
Clermont
Montbrison
M.d'Or
Issoire
Brioude
Loire R.
VELAY
Mauriac
Cantal
Murat
Le Puy
45°
Aurillac
Allier R.
Prades

potamus, together with the ox, various kinds of deer, the bear, hyæna, and many beasts of prey, ranged the forest, or pastured on the plain, and were occasionally overtaken by a fall of burning cinders, or buried in flows of mud, such as accompany volcanic eruptions. Lastly, these quadrupeds became extinct, and gave place to the existing creation. *There are no signs during the whole time required for this series of events of the sea having intervened, nor of any denudation which may not have been accomplished by currents in the different lakes, or by rivers, and floods accompanying repeated earthquakes,* during which the levels of the district have in some places been materially modified, and perhaps the whole upraised relatively to the surrounding parts of France.'

Notwithstanding that 'there are no signs of the sea having intervened,' Lyell says that these 'lacustrine strata, which must have filled a hollow, have been denuded and shaped out into hills and valleys on the site of the ancient lakes.'

This is contrary to the submarine and in favour of the subaerial theory.

Here Lyell is not only in direct contradiction to his submarine theory of the formation of valleys, but also to his *anti-catastrophe* system, and his 'causes now in operation' system; and observe how he changes from one agent to the other. 'During the earlier scenes of repose' he fills his lakes with deposits, and his deposits with fossils, by 'causes now in operation.' But when volcanoes come on the scene to fill the lakes with deposits, he calls in '*cur-*

rents in the different lakes, and floods accompanying repeated earthquakes;' though, as we shall see hereafter, active volcanoes are safety-valves against earthquakes. His very fossils are now entombed by fire instead of water; that is, when they are 'occasionally overtaken by a fall of burning cinders, or buried in flows of mud, such as accompany volcanic eruptions.' Then, to drain the lakes, he darkly refers to 'the era of volcanic eruptions when the lakes were drained.' But a little after he says: 'The subterranean movements may then have continued until they altered the relative levels of the country, and caused the waters of the lakes to be drained off, and farther accumulation of regular freshwater strata to cease.' But he forgets that he had already dammed the water out of the lakes by sediment; and with regard to 'the relative levels of the country,' the Loire and the Allier still run through the deposits *where the lakes were*, qua Troja fuit, with doubtless no farther alteration of level than the enormous one produced by these rivers themselves and rain. But for the shaping of these deposits 'into hills and valleys' after 'the lakes were drained,' Lyell *gives no reason at all.*

But grant subaerial denudation and deposit, and the filling in of the lakes with drift and alluvium, the storing these with fossils of *land* animals, and the cutting of valleys through the deposits, are all matters of course and plain sailing. The wash of

Why valleys grow wider as they descend.

rain and rivers first fill the ancient lakes with drift and alluvium, and the same floods which form the drift store it with *land* animals. But while this was doing, and ever since it was accomplished, rain and rivers have been eroding the dams or barriers which originally formed the lakes. And as these barriers were gradually worn away, channels were cut *longitudinally* through the deposits which filled the lakes. Then come disintegration and the *lateral* wash of rain to *widen* these channels into valleys. And the lower parts of these valleys, speaking longitudinally, and the higher parts, speaking laterally, being gradually and in succession earlier exposed to these wasting causes, *supposing equal hardness of material*, disappear earlier. This is the cause of the increasing width of valleys as they descend; and the very exception proves the rule. For the different parts of the same valley are invariably wide directly as the softness of those parts, and narrow directly as their hardness. This would not be the case if valleys were igneous cracks.

These causes are as hard at work now as they ever were. And in future ages rain and rivers will abstract from these valleys or ancient lakes every particle which in former ages they deposited there. This would not be the case if the Adriatic or any arm of the sea were filled up, because the sea would keep the mouths of the rivers at one level, and prevent them cutting channels through their own deposits.

Many people consider a valley to be like a teacup, or the happy valley of Rasselas,* without an outlet. But valleys are like inclined troughs, open at the lower end. A valley is, in my opinion, a water-slope or a system of water-slopes, converging to one outlet at the sea. In the case of cups or crevices without outlets, formed in the original elevation of the land, rain instantly begins to fill them with water and alluvium. Should either of these reach the lowest part of the brim, rain erodes that brim, makes an outlet, and proceeds to let off the water, or to clear out the alluvium which it has before deposited. This holds true from the largest of the American lakes (for rivers are *subterranean* rain, that is, rain reappearing) to the smallest puddle on a road.

A lake, like a valley, can only have one outlet.

In the first announcement in the papers of the great exploit of the indomitable explorer Captain Speke, it was stated, on the authority of natives, that the Lake Nyanza had more than one outlet. I ventured to suggest that the native information would be found incorrect, and started the principle that, owing to the erosion of the barrier or dam, a lake can only have one outlet. The principle was much discussed, and two lakes, Black Loch in Dumfries, and Loch Davie in Arran, were pointed to as having two outlets. I visited both, and reported

* This was a mistake of mine in the first edition; the great Dr. Johnson contrived an outlet for the water of the Happy Valley.

Source of the Nile or of any river.

that, me judice, each had only one outlet. In the course of the discussion, Professor Jukes said that we should not talk of *the* source of a river; and I so far agree as to think that in talking of it we should define what we mean by *the* source. Every spring is *a* source of a river. My definition of *the* source is that spring, the course of which traced through all its windings is the longest to the sea. The Romans used the words fons and caput in this sense. To say that we must not talk of *the* source of a river is to forbid us to talk of the length of a river, or to compare the length of one river with another. What is the length of a river but the length of its stream from *the* source to the sea?

As might be expected, the ancient alluviums formed in hollows *on dry land* are the grand museums of the remains of *land* animals, as strata deposited in the sea, though equally by the wash of rain from the land, are of the *marine* creation. I would here call attention to these facts, which I shall allude to again in the eighth and thirteenth chapters; and to the fact, also shown here, that the very *museums* of *land* fossils are *transitory*, liable to be destroyed by the very agent which built them—the wash of rain. And because *land* animals are only found in numbers in recent *land* deposits, it is a mistake to argue that they did not exist during and even before the period of the deposit of the most ancient *marine* strata.

Hills and valleys of volcanic district of central France, contrary to submarine and in favour of subaerial theory.

The whole of the thirty-first chapter of the 'Elements' seems written to disprove Lyell's own theory of the *submarine* formation of valleys, and to prove that they are formed by the *subaerial* denudation of rain and rivers. The following are extracts:—

With regard to the Plomb du Cantal, which is a volcanic 'mountain several thousand feet in height,' and which has never been under the sea, and therefore *should* have *no valleys:* 'Valleys radiate in all directions from the natural heights of the mountain, increasing in size as they recede from those heights. Those of the Cer and Jourdanne, which are more than twenty miles in length, are of great depth, and lay open the geological structure of the mountain.'

Speaking generally, he says: 'The lavas may often be traced from the crater to the nearest valley, where they usurp the channel of the river, which has frequently excavated a deep ravine through the basalt. We have thus an opportunity of contrasting the enormous degradation which the solid and massive rock has suffered by aqueous erosion, and the integrity of the cone of sand and ashes, which has in the meantime remained uninjured on the neighbouring platform, where it was placed beyond the reach of the power of running water.'

With regard to the Puy de Côme, a stream of lava fills 'the ancient river-channel for the distance of more than a mile. The Sioule, thus dispossessed

of its bed, has worked out a fresh one between the lava and the granite of its western bank; and the excavation has disclosed in one spot a wall of columnar basalt about fifty feet high. The excavation of the ravine is still in progress, every winter some columns of basalt being undermined and carried down the channel of the river, and, in the course of a few miles, rolled to sand and pebbles. Meanwhile, the cone of Côme remains stationary, its loose materials being protected by a dense vegetation, and the hill standing on a ridge not commanded by any higher ground whence floods of rainwater may descend. At another point, farther down the course of the Sioule, 'the river has excavated a ravine through lava and subjacent gneiss to the depth of four hundred feet. On the upper part of the precipice forming the left side of this ravine, we see a great mass of black and red scoriaceous lava; below this a thin bed of gravel, evidently an ancient river-bed, now at an elevation of fifty feet above the channel of the Sioule. The gravel again rests upon gneiss, which has been eroded to the depth of fifty feet. It is quite evident in this case, that while the basalt was gradually undermined and carried away by the force of running water, the cone whence the lava issued escaped destruction because it stood upon a platform of gneiss several hundred feet above the level of the valley in which the force of running water was exerted. The brim of the crater of the

Puy de Pariou, near Clermont, is so sharp, and has been so little blunted by time, that it scarcely affords room to stand on. This and other cones, in an equally remarkable state of integrity, have stood, I conceive, uninjured, not *in spite* of their loose porous nature, as might at first be naturally supposed, but in consequence of it. *No rills can collect* where all the rain is instantly absorbed by the sand and scoriæ.'

Comparative eternity of cones, owing to their shape.

Lyell here acknowledges the denuding power of rain where it *can* collect in rills. But the *porousness* of volcanic cones is not the sole reason, nor even the main reason, why rain cannot collect on them. Their *shape* is the main reason. I endeavoured to show this in the second edition of the 'Tree-lifter.' I will give one more homely illustration of the theory here.

Suppose a building five yards square, with a single roof like a shed, spouted. All the rain falls into five yards of spouting. Shape the roof double like a gable, the same shed of rain is dispersed over ten yards of spouting. Shape the roof like a four-sided pyramid, the same shed of rain is dispersed over twenty yards of spouting instead of five.

But cones* and cairns have still greater power to *disperse* rain rills than flat-sided pyramids. And

* Bruce says of the houses of Gondar, 'the roofs thatched in the form of cones, which is always the construction within the tropical rains.'

it is to their *shape* mainly that volcanic cones owe their comparative eternity. Comparatively eternal also is the *truncation* of their shape; for this must remain till they are denuded below the bottom of the crater—in many cases many hundred feet; they will then assume the point and appearance of a simple cone of denudation. While this denudation of the crater is going on, supposing equal hardness of material, the rim *should* remain sharp to the last, as Lyell describes many.

How beautifully distinct at any distance is this form of the children of igneous up-throw, whose very uniformity makes variety amid forms resulting from aqueous down-pour. But to aqueous down-pour myriads of them have yielded, and are yielding, and *comparative* eternity is the most perennial claim which can be made to aught existing on a globe, the very being of every department of which, organic or inorganic, is dependent on perpetual change; that is, on perpetual disintegration and reproduction.

In fact the tendency of disintegration and the wash of rain is to form cones out of single hills, and ridges out of chains of hills, with projecting spurs, each spur being itself a ridge ending in a half cone; and even these ridges are so studded with cones as to have a serrated or saw-like outline, and to have earned the modern Spanish, Portuguese, and Italian name of sierra or serra, and to have originated the Latin ex-

pression of per *juga* montium, the very name of hills being taken from the *yoke*-like appearance of contiguous cones. And in this sense, rain may be said to form *hills* as well as valleys. For this reason, though, as Sir Humphry Davy finely remarks, no work of a mortal can be immortal, those works of man which approach nearest to immortality are cones—the pyramid, the tumulus, and the cairn. Why do the imber edax and the fuga temporum pass with so light a touch over these? Because they begin with a form which others end in—a form which is not deformed even by disintegration and the wash of rain.

Cones are the squares into which nature throws solids to resist the rush of aqueous down-pour. Rain, agglomerated in a *steep hollow*, is Napoleon's condensed column of attack, irresistible save to the Iron Duke.

Cliffs on the Seine not marine.

The precipices and columns of chalk which stand out abruptly from the sloping banks of the Seine in Normandy, which Lyell considers as remnants from the surrounding denudation of the sea, exist only because, being harder than the neighbouring chalk, they have yielded more slowly to atmospheric disintegration and the wash of rain. Their comparative hardness is probably owing to the effect of the infiltration of water of petrifying power. Nature is a great chemist, and always at work. Air and water *together* are her great disintegraters, neither of them

singly. In dry air *alone* perishable materials will remain unaltered for centuries, nay, thousands of years; and *under* water wood will retain the sharp edges of the carpenter's work for ages after the upper parts have been turned to powder under the action of the *two* powers. And it is astonishing to what a depth below the surface these two powers *together* will alter even the hardest rocks. They decay into soft mud, earth, clay, or sand. This happens *on* the surface. We see it and believe it. Some of us are rather hard of belief that these soft substances should become hard again *under* the surface; that is, unless melted by heat, or at least *baked* by heat like a brick. Yet the transformation of the soft into the hard without heat goes on under our eyes in nature and art daily. In art, stucco, concrete, cement, plaster, and mortar are daily formed. In nature, petrifying springs turn the softest materials to the hardest in a few hours. Many springs deposit pure flint or limestone. The enormous areas over which water impregnated with iron has acted as a cement may be *seen* by the red and yellow colouring of strata. Place a piece of iron in sand exposed to the elements, and it forms a mass of stone. By the action of heat the purest *looking* water daily encrusts our kettles and cauldrons with intensely hard stone.

But though Lyell describes these rocks as having 'a crystalline texture like marble,' he also describes

them as being, even at this moment, suffering decay and disintegration, and as exhibiting 'a white powdery surface,' and again as being 'in a state of slow decomposition, either exfoliating or being covered with powder, like the chalk cliffs on the English coast.'

To account for the rarity of these so-called marine inland cliffs, and for their intermittent character, Lyell says secondly, 'that precipitous rocks have often *decomposed and crumbled down;*' and thirdly, 'that many terraces and small cliffs *may* now lie concealed beneath a talus of detrital matter.'

Here we get subaerial denudation and its effects. And this is the true history of *all* denudation. These taluses are of very constant occurrence, as I stated in the second edition of the 'Tree-lifter,' and may be shown where they do occur, because they are unstratified. But what formed them but subaerial denudation? Or in plain English, the decay of the faces of the precipices, or 'the run of the hills,' above them, or both.

In general the philosophic and the unphilosophic are terribly put out by the powers here claimed for 'the wash of rain.' Yet when the word 'flood' is used, they will allow you to wash away articles of any size or description, natural or artificial. A flood, however, is simply the effect of rain, as '*the flood*' was the same.

If only one year's rain could remain where it fell,

the surface of the whole terraqueous globe would be covered a yard deep with fresh water. Is this so small a cause as to produce no effect?

CHAPTER III.

DENUDATION OF WEALD RUNS THROUGH RIDGES WITHOUT PONDING.

THE WEALD ORIGINALLY COVERED WITH TERTIARY STRATA. ORIGIN OF THE DRUID SANDSTONE. TERTIARY STRATA ORIGINALLY UNITED THE BASINS OF LONDON, PARIS, AND HAMPSHIRE. THE WEALD *VALLEY*, NO VALLEY, BUT A *HILL*. AND ITS DENUDATION PASSES TO *TWO SEAS* BY NUMEROUS DISTINCT TRANSVERSE VALLEYS. THESE VALLEYS WERE MADE BY RAIN AND RIVERS, NOT BY THE SEA, NOR BY 'MATHEMATICAL EARTHQUAKES.' THE SEA IS ERODING THE COAST OF SUSSEX. THE SEA ERODES THE *OUTSIDE* OF THE LAND NOT THE *INSIDE*. YET THE RIVERS ARE FILLING THEIR ESTUARIES. THE GRADIENT OF A VALLEY IS NEVER PERMANENT IN ANY PART. HOW RIVERS RUN THROUGH RIDGES OF HILLS EVEN WITHOUT PONDING. THE HARD GORGE AND SOFT VALLEY THEORY. THE 'WEALD VALLEY' MAY BECOME THE 'OOLITIC VALLEY.' MANTELL'S '*DILUVIAL*' VALLEY. THE *AXIAL* VALLEY OF THE ROTHER. ROMNEY MARSH THE DELTA OF THE ROTHER. EMBANKMENT OF *NEW* LAND STILL GOES ON. ONLY *MUD* GOES OUT TO SEA. THE CHALK FLINTS WHICH COVERED THE WEALD *HILL*. THE ITCHEN ONCE ROSE ON THE WEALD *HILL*. THE WATER-SLOPE OF THE ARUN IS STILL ROBBING THE WATER-SLOPE OF THE ITCHEN. ROMNEY AND HYTHE *ONCE* CINQUE PORTS. THEY *NOW* BEAR SHEEP NOT SHIPS.

To denude the Weald, Lyell uses his own *submarine* theory, but not alone. *Fiat mixtura*. He adds a *quantum sufficit* of the mathematical earthquake system of Messrs. Martin and Hopkins. Later in the

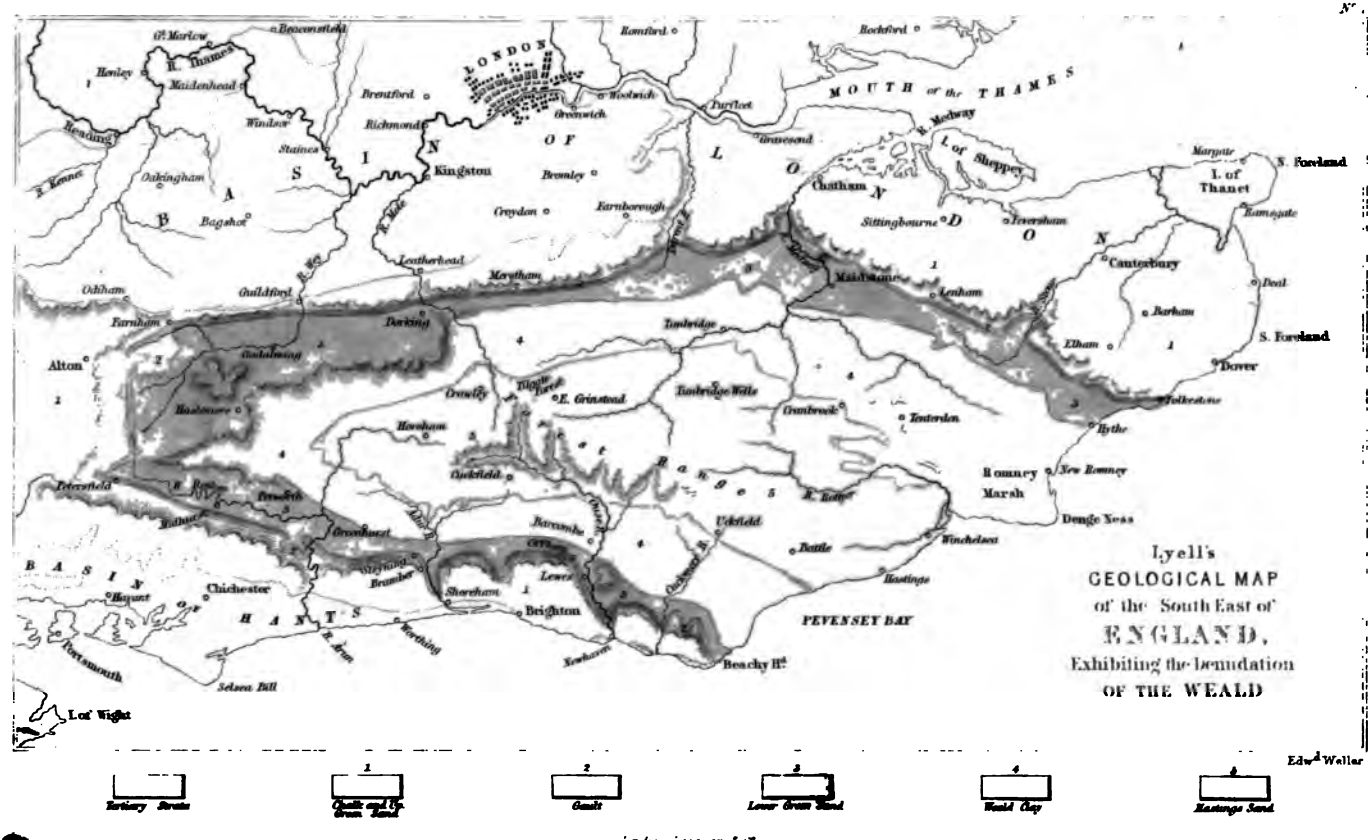
day, in Calabria, we shall find the dose of earthquake made up with *aqua pura*, that is, with 'running water,' or *the erosion theory*.

In the original elevation of the Weald district, the igneous action was strongest from east to west along the centre of the yellow Hastings sand, No. 5, where 'Forest Range' is marked in the map; so that it formed there what is called an anticlinal line or axis; that is, the beds or strata were raised highest along the ridge, and inclined or *dipped*, like a barn roof, both ways, to the north and south, while they *stretched* to the east and west. The conventional term 'line of strike' is a bad translation by sound instead of by sense, from the German *streichen*, and means line of *stretch*.

The lips of the light blue Weald clay, No. 4, originally joined over this ridge of the Hastings sand; those of the green lower greensand, No. 3, over the Weald clay; those of the dark-blue gault, No. 2, over the lower greensand; and those of the light coloured chalk and upper greensand, No. 1, over the gault.

The Weald originally covered with tertiary strata.

Lyell thinks that the pink tertiary strata did *not* join over the chalk, because they may have been deposited from his favourite marine denudation after the chalk was raised. He writes: 'This idea receives some countenance from the fact of the tertiary strata, at their junction with the chalk and the London and Hampshire basins, often consisting of



Lyell's
GEOLOGICAL MAP
of the South East of
ENGLAND,
Exhibiting the denudation
OF THE WEALD

Edw^d Weller

dense beds of sand and shingle, as the Addington hills, near Croydon. They also contain occasionally fresh-water shells, and the remains of land animals and plants, which indicate the former presence of land at no great distance, some part of which may have occupied the centre of the Weald.' The very facts which Lyell here adduces to prove these beds to be the result of his favourite *submarine* denudation, I think prove them to be beds of drift, *deposited on dry land*, from *subaerial* denudation, that is, the wash of rain.

This subject, under the head of drift and alluvium, will be considered in the fourteenth chapter. But as mistakes are constantly made between drift, alluvium, and tertiary strata, and as it is perhaps impossible strictly to distinguish between them, I will state here the sense to which I shall *endeavour* to confine myself when I use the words. *Drift* is coarser alluvium, *driven* along the beds of rivers or overflows by strong floods, and *deposited on land*, or left in valleys, where the finer materials have been washed away, in both cases unstratified. Alluvium is finer drift, partially stratified, *deposited on land*, from materials held in suspension by water running or *standing for a time*. The deposits of alluvial plains are alluvium, though enormous quantities of drift may be mingled with them. Tertiary strata are deposits from water in water; but so are all new alluviums in the sea and in lakes. Nay, in lakes

the deposits near the shores partake very much of the character of drift, beyond this of alluvium, and in the centre they are perfectly stratified. Where are we to draw the line in these cases? and especially where are we to draw the line between new alluvium in the sea and tertiary strata? There is, however, a clear line between deposits on land and deposits in water; and to deposits on land I confine the words drift and alluvium. The enormous beds of drift and alluvium *deposited on land*, contiguous to river-courses, and resulting from the formation of valleys, &c., are constantly quoted as tertiary strata.

I contend, however, that the lips of the pink tertiary strata must have joined over the chalk, making these strata of the London basin and the Hampshire basin continuous over the Wealden ridge (not valley). The Alton hills, which form the west border of the Wealden region, are still capped with the last remains of tertiary strata. And doubtless the so-called Druidical sandstones and conglomerates of this otherwise chalk district are remnants of these tertiary beds.

Origin of the Druid sandstone.

In the horse monument at the foot of Brookwood Hill, I brought the largest of the sandstones from the top of the clay-capped chalk ridge north of the road between East and West Meon. The next largest flat one I dug out from two feet below the surface of the drift-gravel on the east side of Bram-

dean. It may, perhaps, have never moved horizontally, or very slightly, but have been gradually and constantly undermined during the excavation of the valley, and so let vertically down. A large stone so situated may be rounded by the passage of water, sand, and small stones in floods, and by the action of the atmosphere, and so assume the form of a huge boulder without having been itself moved. And where extensive regions of *soft* strata vanish by denudation, they will leave any accidental rocks or hard parts of their contents behind them in the form of huge boulders.

To illustrate this in a small way: the drift at the bottom of one of our Hampshire deans or valleys may contain a sifted assortment of the contents of the whole mass which once was above the valley, as well as 'the run of the hills' which now form its sides; so that, of two flints there lying in contact, one may be the untravelled, angular nodule of the secondary chalk, the other the travelled, rounded pebble of the tertiary clay.

A large sandstone may be seen in the cutting for the road on the brow of Filmere Hill, between West Meon and Alton, with perhaps fifteen feet of clay above it. This is no *bunch* (in mining terms) of clay, but extends on all sides, except where valleys interfere. Indeed, I think it may be traced on the tops of the hills from the London to the Hampshire basin. At any rate, it extends in the direction of

Froxfield, where many other such stones protrude from the clay, to the very border of the Wealden region. Since this was published I have added many of these stones to the horse monument. They were blown to pieces to get them out of the way of the owner's plough. They vary from the finest and purest sandstone to coarse conglomerate, and clearly show their tertiary sea-shore origin. They have been run together in nodules by water impregnated with iron, flint, or carbonate of lime, and in great storms have been washed out into the deep water where the clays were in deposit like the sand of the 'plastic clay *and sand.*' In the interior of these stones are many holes with loose sand and rounded pebbles which the petrifying water did not reach.

Between Rotherfield and Alton, in Brightstone (Bridestone)* Lane, is a collection of large conglomerate stones.

* Brida, or Fraida, or Freia, or Friga, was the Saxon planet and Goddess Venus, who gave her name to Friday (dies Veneris, Venerdi). She was Christianised and canonised under the name of St. Bride and St. Bridget, or St. Fraid, and was the virgin as well as Venus. Woden was the Saxon planet and god Mercury, who gave his name to Wednesday (dies Mercurii, Mercordi). He was canonised under the name of St. Michael, and was Mithras as well as Mercury. All that was sacred in Sabiism, that is, in the Mithraic, or planetary, or astral, or Druidical, or fire worship, was divided between these two Christian saints. Bride-stones and Bride-wells (springs) are universal. The origin of the name of Bridewell for a prison, is that the Royal palace in London of St. Bride's-well in Fleet ditch, became the great city prison. The parish of St. Bride is the parish of St. Venus.

Tertiary strata originally united the basins of London, Paris, and Hampshire.

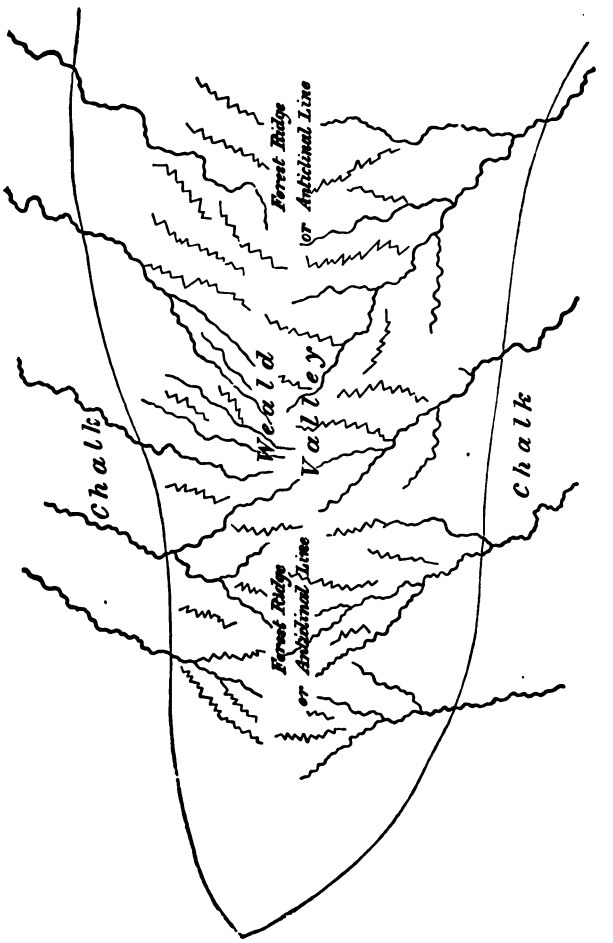
The chalk hills of the opposite coast of France and Belgium, and the banks of the Seine in Normandy, are also still undenuded of their cap of tertiary strata; and, according to my view, it is very probable that these strata of the Paris, the London, and the Hampshire basins once united over the chalk. But as we may almost say that the Weald is *at the present time* surrounded by tertiary strata, there is, I think, every presumption that in *former times* these strata covered this 'valley of denudation,' as Lyell calls it. A more complete misnomer, however, could not be. Every valley, indeed, is a valley of denudation; which denudation has passed out of the valley through a single outlet or waterslope. For it is an essential characteristic of valleys, trunk or branch, that however infinite the tracery, and however countless the number of their ramifying *upper inlets*, each and every valley *can* have but *one lower outlet*. I speak as regards the flow of water and of denudation.

'The Weald Valley' no valley but a hill,

But the Weald is no valley at all. If it is any *one* thing, it is the reverse of a valley. It is a hill with, if not a quaquaversal dip, at least a quaquaversal waterflow; that is, its waterflow and denudation, like those of most other large hills, are carried to the sea by a great number of distinct trunk valleys. And actually the four southern valleys of this 'valley of denudation' discharge themselves into the English Channel, the five northern ones

and its denudation passes to two seas by numerous distinct trunk valleys.

MR. MARTIN'S IDEA OF 'THE WEALD VALLEY.'



into the Thames and German Ocean, while the eastern Rother forms a delta of 60,000 acres under the name of Romney Marsh.

No one who knows the alphabet of physical geography can cast his eye on the foregoing map, taken from Lyell's 'Elements,' without seeing this fact. But I add Mr. Martin's own particular sketch to show how, according to him, the 'Weald *valley*' consists of the very *top* of the 'Forest *Ridge*;' the exact summit which separates the north and south waterslopes, and which it is the present fashion to call a *portage*. And if anything can be the exact reverse of a valley, a portage is the exact reverse of a valley.

The Humboldtian Keith Johnston explains the meaning of the word portage. Navigators have there, he tells us, 'the advantage' of being *obliged* to *carry* their vessels, as well as their cargoes, overland from the river on one side of the portage to the river on the other side.

But whether the Weald *hill* was originally capped with tertiary strata or not, it is allowed by all that it was capped by the beds which I have enumerated from the chalk to the Hastings sand, and that these beds have vanished by denudation. Therefore, before this prodigious denudation took place, and while it was taking place, the ridge above the 'Forest Range' was incomparably the highest ground in the region. Naturally, then, the waterflow, whether of

the surface (rain and snow), or from under the surface (springs and rivers), would be from this highest point, the Forest Ridge, to the lowest point, the sea. And this waterflow is not only to the north and south, as represented by Mr. Martin; it is to the east and west also. From Tilgate Forest there is a quaquaversal waterflow to the sea, by means of many different trunk valleys, formed and graduated by the wash of rain. And the courses of this waterflow once made would be continued during the rise of the land, notwithstanding that, owing to a cause which will be explained, their starting-point might have been denuded some feet lower, not than their beds, but than the heights through which their beds pass. That the main drainage of the Forest Ridge *does* pass through the North and South Downs, which are masses of uniform structure and hardness, is a fact which of itself proves that the waterflow made its own courses. The sea could not have made them unless their original contents had been softer than their sides. Mr. Martin, indeed, points out that the *four* southern rivers are exactly opposite the *five* northern rivers. And Mr. Hopkins proves, 'by mathematical methods,' that 'cross fractures' *must* have occurred where these *nine* rivers pass through the Downs. And Lyell agrees, that, owing to the loosening of the materials, the *sea* has been enabled to make the nine river-courses. But, first, any two *points* are opposite one another. But if we take the tortuous *lines*

These valleys were made by rain and rivers not by the sea.

Nor by mathematical earthquakes.

of the rivers, they are *oppositer;* for they are opposite all the points of the compass. And as for the eight or nine 'cross fractures' there is not a particle of evidence for the existence of any one of them.

'The pressure of superincumbent strata of unknown thickness and kind, must also be taken into account; and it will not be thought wonderful that diluvial action and the operation of more modern causes apart, *there should be so little direct evidence of fissure upon the surface.*'

Mr. Martin here talks of *little evidence;* but he actually produces *none whatever.*

It is true that a fracture and a fault are claimed in the valley called 'the Coombe;' but there is no river there, nor is the fracture a 'cross fracture,' but a longitudinal fracture, running east and west.

Supposing all these longitudinal fractures to have rivers as well as the cross 'fractures,' which on mathematical principles they should,

To one who looked from upper air

what a pretty effect the symmetrical, fluvial reticulation would have! like a net on a lady's head. What would be the mathematical name which the interstices between the intersections would assume?

The pompous* Humboldt cracks out his conti-

* 'Professus grandia turget.' In almost the first words of the

nental watercourses still more ridiculously. Indeed, his ideas on the subject appear to me like the ravings of madness. It may be asked, Why then waste time on the ravings of madness? and I beg pardon for doing so. But the reply is, that in discussing the theory of rivers and the formation of valleys, the opinions of Humboldt cannot be passed in silence, and particularly when (alas!) we find Lyell sharing in those opinions.

Cause of the direction of rivers and valleys.

Humboldt writes ('Cosmos, Physical Geography'): 'The main direction of the whole continent of Europe (from south-west to north-east) is opposite to that of the great fissures which pass from north-west to south-east, from the mouths of the Rhine and the Elbe, through the Adriatic and Red Seas, and through the mountain system of Putschi-koh, in Luristan, towards the Persian Gulf and the Indian Ocean. This almost rectangular intersection of geodesic lines exercises an important influence on the

'Cosmos,' Humboldt declares his intention to describe nature '*in exalted forms of speech.*' He accordingly gives loose to a barbarous jargon of words, the mixture of verbis græca latinis, which Demosthenes and Cicero together would be puzzled to interpret. I do not mean that he is *singular* in this. Such gaudy frippery may hide and cloke the deformity or weakness of the false, but can it deck or dignify truth and nature? Gild refined gold, or throw a perfume o'er the violet! But this nomenclature, or, as Lyell calls it, *terminology*, is not only *useless*, as it conceals the laws of nature (which are as simple as they are sublime) behind the double veil of Greek and Latin—it is a hideous iniquity, for it effectually shuts out from the vast majority of mankind truths which *might* be known and *should* be known by *every* man, woman, and child.

commercial relations of Europe and Asia and the north-west of Africa, and on the *progress* of civilisation on the *formerly* more flourishing shores of the Mediterranean;' that is, *formerly* Rome, Carthage, Greece, Phœnicia, and Egypt, owed their civilisation to the 'great fissure' formed by *the Alps*, the Rhine, and the Elbe. And to these we are indebted for the present '*progress* of civilisation' around the whole 'shores of the Mediterranean.'

But are there no rivers in Europe save these two German ones? The Dnieper would swallow both. And if the Spree and Potsdam had appertained to the Dnieper instead of to the Elbe, perhaps the Vistula, the Dnieper, and the Black Sea would have formed the 'rectangular intersection of geodesic lines.' The Danube, which would also swallow both, and the Po, are in *the same line* as 'the main direction of the whole continent of Europe.' And the Volga, which again would swallow both, and Don, form 'a rectangular intersection' of Humboldt's 'great fissure.' The 'great fissure' between the Adriatic and the Rhine is precisely the highest part of Europe—the Alps.

But is the writer of 'Cosmos' to consider 'the main direction' of the land and water of Europe separately from that of the land and water of Asia (which contains how many of the largest rivers in the world), because man has divided this one continent into two by a difference of names?

On whichever side of high land the sea is, the water-flow must go to it. This is the sole and simple secret of the *direction* of rivers and valleys. And the principle applies to the inland seas and lakes of central Asia, as well as to the great oceans. If the sea is close to high land, as the Pacific to the Andes, an infinity of small streams run straight to it. If distant, as the Atlantic, the infinity of small streams, in seeking the sea, fall together, and form large rivers, collecting as they go the waterflow of the regions through which they pass. The Pacific side of the Andes *cannot* have large rivers. The Atlantic side *must* have large rivers. Thus a long river is a strong river, because vires acquirit eundo, and it gets *wider* as it descends. But if river-courses were igneous cracks formed in the elevation of the land, these cracks of construction should get *narrower* as they descend, and they should die off to nothing at the sea. The crack of the River Plate is 170 miles wide at the sea; and, like all other rivers, instead of widening, as an igneous crack ought, it narrows as you proceed inland. The crack of the Amazons is at the sea perhaps 150 miles in width, and it is three or four miles wide at the foot of the Andes, and there narrows to a few hundred yards. If you follow one stream, it narrows off to nothing, that is to one spring. Does this one spring, with the spring on the opposite side of the mountains, form 'a great fissure' through the Andes from the Atlantic

to the Pacific? And so the thousand springs of the Amazons with their opposites a thousand 'great fissures?' If so, why do the western halves of these 'great fissures' run straight to the Pacific sea, and their eastern halves converge to the trunk line of the Amazons? Perhaps Mr. Hopkins will 'account for this by mathematical methods.' But if we consider the entire head of the Amazons as one 'great fissure' a thousand miles wide, how comes this fissure to be filled with the highest mountains of the New World?

Take Europe and Asia as one continent, of which, in another page, Humboldt himself says, 'its major axis is almost parallel with the equator,' and are the rivers of China and the west of Europe *at right angles* with 'the main direction' of the land? If we could jump mountains as easily as Humboldt does the Alps, we might crack the continent *in the same line* as its main direction, from the Loire or Tagus to the Yang-tse-kiang or Amour, by the rivers of the Black Sea and Caspian, or in any other direction we require. If we trace the 'great fissure' from the Ægean, by the Don and Volga, to the Oby, besides forming 'a rectangular intersection' with Humboldt's 'great fissure,' we might account for the high state of civilisation of the Crimea and Siberia. If you jump from the Japanese, or from the Irawady to the Yenesei, or to the Irtish branch of the Oby, you make a real *Cosmical* leap, and a 'great

fissure' well worthy of Humboldt, instead of his petty *European* Alpine hop.

As every continent is surrounded by sea, any two rivers running from any height to opposite seas must form a '*great fissure*,' if we may jump the height. If we trace any two rivers from opposite seas, to where they nearly meet at their sources, we come to a portage. Are a portage and a fissure synonymous? I should say that a portage is the reverse of a fissure. It is at least the highest ground in the neighbourhood, if not on the continent.

I am, however, straining at a gnat in not swallowing these superficial *transverse* fissures, which pass *over* and across mountain-*tops*. Now for the camel. Humboldt has seen so far into the millstone as to discover that every mountain-chain is *supported* by a *longitudinal* fissure *below* it. In talking of earthquakes, he says: 'As mountain-chains appear to be raised on fissures, the walls of the cavities may perhaps favour the direction of undulations parallel to them.' The great mountain *fissure* of the New World extends from within the arctic circle to near the antarctic circle—10,000 miles. If thermometers were sunk at intervals of 1000 miles through this fissure into the interior of the earth, we might arrive at valuable isogeothermal (Chthonisothermal) facts. The experiment might be first tried at the plain of Malpais, which,

with Mount Jorullo at its centre, 1600 feet high, was raised by eruption in 1759. Humboldt 'attributed the convexity of the plain to *inflation from below;* supposing the ground, for four square miles in extent, to have risen up *in the shape of a bladder* to the elevation of 550 feet above the plain in the highest part.'* Or at home we might try it on the Weald hill, where, owing to denudation, we must be near the 'fissure' of construction, or perhaps in this case the *foundation* would be another '*bladder*.'

But to return to the superficial fissures of the Weald. Of the Arun it may be said, that one of its

* Humboldt (Cosmos) quotes Plato, Aristotle, Pausanias, Strabo, and Ovid to prove that the inside and foundations of mountains are wind, and regrets that he cannot quote the non-extant work of Theophrastus. He himself translates Ovid's description of the elevation of Mount Methone, in prose, thus: 'The heaving earth, inflated by the force of the compressed vapours, expands like a bladder filled with air, or like a goat-skin. The ground has remained thus inflated.' In a note, Humboldt adds Dryden's poetical translation, which gives the mountain a *pain* in the stomach from flatulent colic :—

> 'Labours with colic *pangs*, and close confined,
> In vain sought issue for the rumbling wind.'

Humboldt then gives Aristotle's own words for 'the rumbling wind' (ἄνεμος and πνεῦμα), and ends with Strabo's assertion that, by day, it emitted a 'sulphureous stench, but by night evolved an agreeable odour.' Humboldt's commentary on Ovid is, 'this description of a dome-shaped elevation on the Continent is of great importance in a geognostical point of view.' And on Aristotle, 'in this description, *the vesicular distension* of the earth's crust, a stage at which many trachytic mountains have remained, is very well distinguished from the eruption itself.' And this is the modern Pythagoras, the *Master* by whose word science swears!

arms runs from east to west ; another from west to east; and its body from north to south. We cannot, then, deny that this river is opposite whatever river Mr. Martin pleases.

Indeed, I am willing to concede that *any one* of the myriads of valleys branching from the Forest Ridge, or from the North or South Downs, or from the Alton Hills, is opposite to *any other* which Mr. Martin pleases; though I should hesitate to agree that any of these valleys resulted from fractures, cross or longitudinal.

The western branch of the Arun (called the Rother—not that Rother flowing from the Forest Ridge eastward) rises at Nore Hill, near Rotherfield, in Hampshire. So does one branch of the Wey. And these two rivers have nothing to do with the drainage of the Forest Ridge, but merely receive the run of the south side of the North Downs, and of the north side of the South Downs, and so develop these two ridges *behind* the gorges; an operation which will be alluded to at the end of this chapter.

I presume that Mr. Martin will have some fracture,—either a longitudinal fracture, or a cross fracture, or a diagonal fracture,—for the little stream which rises near East Meon, above the P. of Petersfield in Lyell's map. It surely is opposite the eastern arm of the Arun, or the western and the eastern Rother, and forms a 'great fissure' in the same

line, and directly along the anticlinal axis of the Weald *valley*. Or else it is opposite one of the branches of the Wey, or else one of the tributaries of the Thames above Odiham. However wedded I may be to my own theory I cannot deny facts; and Mr. Martin has only to say which of these rivers is opposite to this stream, and I can no more gainsay it than I can object to the conclusions drawn by Mr. Hopkins's 'mathematical methods.' Though I must say that I think that if Nature had drawn the lines of valleys by 'mathematical methods,' she would have ruled them straighter than Britannia rules the waves, or than the lines of actually existent valleys are.

In Norway and Sweden, raised beaches show that the land is rising for the space of about 1000 miles. These beaches are found 600 feet above the sea. The present rate of rising is thought to be four feet in a century. If this had caused 'fissures' or 'cross fractures,' they should not only be existing now, but greatly widening. Yet there are no more fissures there than in any other system of valleys. It is needless to remark, that a rise of four feet in a century would in no way disarrange the drainage of the country. And it has required all the sagacity of the greatest philosophers to ascertain that this vast operation *has* taken place, and *is* still progressing.

I must confess that I have not had an opportu-

nity of examining these 'mathematical methods' of Mr. Hopkins's. But according to my mathematics, if the valleys of the river-courses of the Weald are igneous fissures, they should grow wider as they ascend. They should be widest at the top of the Forest Ridge, and should *narrow* off to nothing at the sea on the south, and at the Thames on the north, and this irrespective of comparative hardness of ground. The reverse of this is the case. Like any other waterslopes, these valleys start without any fissures at all; that is, the run of the whole *surface of the high grounds* is first received into an infinity of coombs, which have no permanent streams; and all these coombs, *running from every direction*, slope into a multiplicity of narrow valleys with rivulets, *also running in every direction.* And, like any other waterslope or system of valleys, instead of narrowing, they widen as they descend, except where the ground is harder than the ground *above* it, that is, *up stream* of it. The reason for this will be given immediately.

Lyell says: 'It is evident that these openings, so far at least as they are due to aqueous erosion, have not been produced by the rivers, *many* of which, like the Ouse, near Lewes, have filled up arms of the sea, instead of deepening the hollows which they traverse.'

As these rivers have filled up arms of the sea, I have given a reason why they never *can* deepen

their channels at the mouths as long as the sea and land keep their present relative level. More than this: instead of deepening their channels, they will build their banks *and beds* up higher than they are, as the rivers in alluvial parts of valleys always must at every overflow. But this subject will be considered in the last chapter.

The sea is eroding the coast of Sussex.

According to Lyell, the sea is at present eroding the coast of Sussex. The following is from the 'Principles.' 'About a mile to the west of the town of Newhaven the remains of an ancient entrenchment are seen on the brow of Castle Hill. This earthwork, supposed to be Roman, was evidently once of considerable extent, and of an oval form, but the greater part has been cut away by the sea. The cliffs, which are undermined here, are high; more than 100 feet of chalk being covered by tertiary clay and sand from 60 to 70 feet in thickness. In a few centuries the last vestiges of the plastic clay formation on the southern borders of the chalk of the South Downs on this coast will be annihilated, and future geologists will learn from historical documents the ancient geographical boundaries of this group of strata in that direction. On the opposite side of the estuary of the Ouse, on the east of Newhaven harbour, a bed of shingle composed of chalk flints, derived from the waste of the adjoining cliffs, had accumulated at Seaford for several centuries. In

the great storm of November, 1824, this bank was entirely swept away, and the town of Seaford inundated. Another great beach of shingle is now forming from fresh materials.

'The whole coast of Sussex has been incessantly encroached upon by the sea from time immemorial; and, although sudden inundations only, which overwhelmed fertile or inhabited tracts, are noticed in history, the records attest an extraordinary amount of loss. During a period of no more than eighty years, there are notices of about *twenty* inroads, in which tracts of land of from twenty to *four hundred acres* in extent were overwhelmed at once.'

Yet the rivers are filling their estuaries.

With this devastation going on in these days, one would suppose that if in former days the sea made the valleys of the Ouse and the *many* other rivers in its neighbourhood, if it did not continue to erode and enlarge these valleys, it would at least keep them open.

The sea erodes the *outside* of the land, not the inside.

But the sea erodes the *outside* of the land, not the *inside* of it. The erosion of the sea, speaking liberally and by comparison, is horizontal, and parallel to the line of coast. Speaking in the same way, the erosion of rain and rivers is vertical, and at right angles to the lines of coast. That is, as far as concerns the trunk-ends of rivers and their valleys. Instead of eroding the inside, the sea, which is devouring the *outside* of the land, has allowed the rivers to dam it out of the *inside* of it,

to fill up arms of the sea. And with what *materials* have the rivers filled these arms of the sea, since they have not 'produced the openings,' and are not 'deepening the hollows which they traverse?' But parvis componere magna: let us ask this question on a larger scale. If the sea made the valleys of the Rhone, Po, Mississippi, Ganges, and Niger, why does it yield to these rivers now, and allow them to protrude deltas of thousands and thousands of square miles? One answer replies to both questions.

Though the Ouse *must* cease to deepen its channel where it is level with the sea, at this present time there is not a heavy rain falls on the upper valley of the Ouse, but it deepens, lengthens, and widens that valley. And this is the case, not only with that valley, and the valleys which I have enumerated, but with every valley in the wide wide world. And hence the *materials* which fill arms of the sea, and form alluvial plains and deltas, unless the land is rising, or alongshore currents and tides interfere by sea, or lakes catch the alluvium by land. The gradient of a valley is never permanent in any part. Every valley is always lengthening at the upper end or decreasing in height there; and all intermediate parts are perpetually in process of being planed down, or built up, to one uniform gradient from the head of the valley to its mouth, or to the end of the delta, if there be one.

The gradient of a valley is never permanent in any part.

Valleys are always increasing, hills always decreasing. Indeed, valleys exist only in the dissolution of hills. But sedimentary strata are not formed only from the contents of valleys. The entire surface of the solid part of the globe—the earth, is always being washed by rain into the liquid part of the globe—the sea. As sure as there are alternations of hard and soft strata in the course of a river or valley, so sure will there be alternations of gorge and alluvial flat.

How rivers run *through* ridges of hills even without ponding, as in the Weald.

We are not to imagine that it is in the Weald only that rivers run *through* ridges of hills. A glance at a physical map of England or the World, will show plenty of examples. Take for instance the ridge of *hard* oolite and chalk which forms the gorge of the Humber, the affluents of which in flowing from the Pennine chain have formed the plain of York in the *soft* triassic strata. Or take the gorges of the Clyde and Mouse water at Lanark which have caused the so-called Kames at Carstairs. Is Mr. Hopkins going to account for these 'cross-fractures' by 'mathematical methods?'

A stream running *through* ridges, large or small, is the simple consequence of the differing hardness of the ground through which it runs. In all cases a stream cuts for itself a narrow channel, the depth of which is determined by the hardest part. For a stream cannot run down where its bed is soft, and up again where it is hard. But the wash of rain

digs down where the ground is soft, and leaves hills or ridges where it is hard. And as a transverse stream cuts through a hard stratum, say the North or South Downs, the wash of rain is scooping out two longitudinal valleys *behind* it, that is, a valley behind each side of the gorge and ridge, as in the Weald clay.*

The hard gorge and soft valley theory.

Such are the valleys along which the western branches of the Arun and Wey flow. Such are the valleys of the greensand and gault and the *flats* of the Weald clay behind the gorges of the South Downs in Sussex, and of the North Downs in Surrey and Kent. But in this *small* map only *large* streams are marked. The *débris* of these valleys is carried off by the lowering bed of the river. A ridge is then developed, and the river runs through a gorge in the ridge. In this sense the wash of rain may be said to form hills as well as valleys, since by abstracting intervening masses it develops them, as, by abstracting intervening Weald clay, the wash of rain has cut the one original ridge or hill into three main ridges, namely, the two chalk ridges and the Forest ridge. And in *forming* a statue what does the sculptor do more? The ridges then, instead of being considered as barriers to the river, have been actually *formed* by the river by the abstraction of intervening masses. Except the

* Mr. Mackintosh has dubbed this 'Colonel George Greenwood's hard gorge and soft valley theory.'

branch of the Wey at Farnham the rivers all run *out* of the Weald from geologically lower strata across geologically higher strata, and in passing from the geologically lowest strata—the Hastings beds—these transverse rivers deposit drift gravel and alluvium first in the soft valleys (with longitudinal branches) which they have formed in the geologically higher Weald clay, behind the hard gorges of the geologically higher greensand. And secondly, they deposit in the soft longitudinal affluent valleys which they have formed in the geologically higher gault clay, behind the hard gorges of the geologically higher chalk. But at Farnham this is reversed. The Wey runs *into* the Weald from geologically higher strata across geologically lower strata, and it has deposited vast quantities of drift gravel and alluvium in the soft valley of the gault clay behind the hard gorge of the lower greensand, instead of behind the chalk, as the rivers have done in all the other nine cases. A ridiculous common error supposes these gravel terraces to mark the *overflow* of the rivers in a 'gravel period' formed by a 'pluvial period.' They are the ancient river *beds*. *Drift* is *driven*. Gravel does not nor ever did *flow* on surfaces of rivers. But rivers do flow on surfaces of gravel even at the present period.

The gorges, cut through comparatively hard beds or ridges, form exceptions to the widening of valleys

as they descend. That is, directly as the hardness of the beds through which the same valley runs will be the narrowness of that valley; directly as the softness, the width. Above each hard gorge will invariably be a comparatively wide horizontal valley filled with an alluvial flat caused by the check of the flood water at the gorge. As the gorge is cut lower the alluvial flat will be cut through, and will vanish in the form of two parallel terraces. Another alluvial flat will be formed at a lower level, that also hereafter to vanish as parallel terraces, and as has been said (p. 34) these exceptions prove the rule that valleys are made by water and not by fire. For where valleys run across strata of different hardness, if the valleys were igneous cracks they would not vary in width or even in height of their sides according to the softness or hardness of the strata. The sides of the valleys across the Weald clay should be as high as in the gorges across the chalk if the valleys were igneous cracks.

The great height of some of these ridges, though a *proof*, is a very inadequate *measure* of the enormous denudation which has gone on *behind* them, since the ridges themselves have suffered enormous denudation.* The tops of all such ridges must

* As I published in the Athenæum in 1863, 'The power of denudation is by no means appreciated. All geologists follow Lyell in his dictum that denudation and deposit are equal and are the measure one of the other. Indeed Darwin calls this a profound

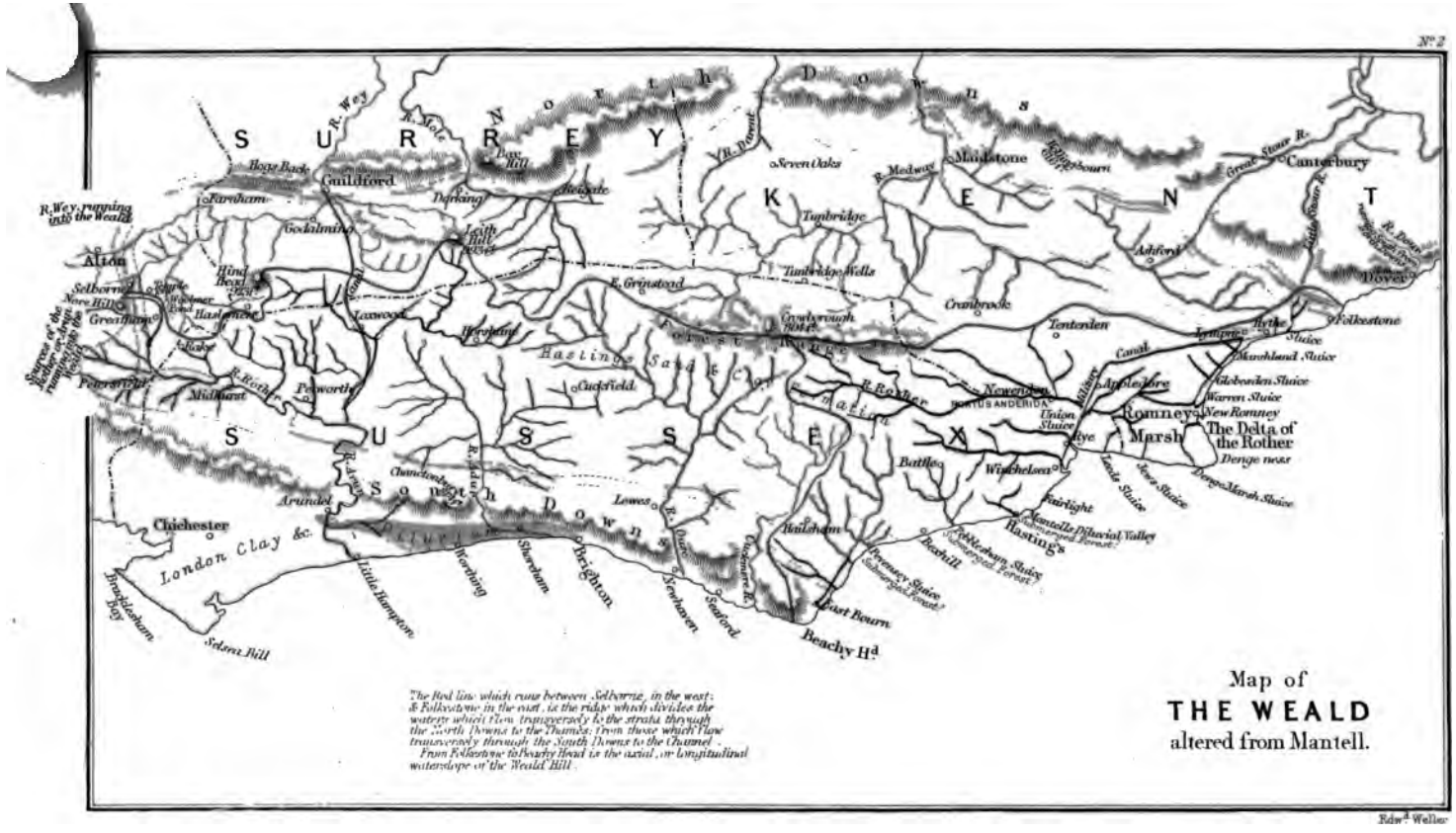
originally have been lower than the hills from which the rivers rise. But whether all or any of them continue lower, and their comparative height one with the other, will depend simply on which is the hardest, that is, which is most quickly disintegrated and denuded; the hills from which the rivers rise *might* be denuded as low as the beds of the rivers in the gorges.

The '*Weald valley*' may become 'the oolitic valley.'

Suppose this to happen in the Weald. The Forest *Ridge* of Hastings sand might then become a marsh, on an oolitic bed; and 'the Weald valley,' 'the oolitic valley.' It is not likely that it would then feed more than one outlet; but if it still retained its present ten outlets (for I consider the eastern Rother as one), I will make this possible valley with ten outlets a present to those who object to my definition of a valley.

These causes produce a comparatively uniform slope of the bed of a river to the sea, with every species of irregularity of its banks and the region through which it flows. This is the very fact which proves the aqueous origin of the river beds and valleys, as has been finely remarked by Playfair on Hutton. It is impossible that earthquakes should have formed these continuous slopes to the

remark. But it is a profound mistake; it would only be true if deposits were never denuded. But denudation is almost always employed on deposits, and past denudation exceeds existing deposits by an infinite multiple.'



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sea through every different height of banks—this wonderful regularity passing through this wonderful irregularity.

But I can find no hint that Playfair thought 'parallel terraces' to be the remains of alluviums caused by the hard gorge and soft valley theory. On the contrary, he generates (?) the present fashionable doctrine (page 352), he pronounces the terraces to be the remains 'of a series of lakes, which have been converted into dry ground,' and states that they 'make it certain that the great mass of gravel which forms the successive terraces on each side of the river was deposited in the basin of a lake.'

Mantell's 'diluvial' valley.

Mantell tells us that at Hastings '*a diluvial valley* intervenes between the white rock and the west cliff, where the ruins of the castle are situated.' *Diluvial!* Beautiful! A valley made by Noah's flood doubtless! At least it cannot be an igneous crack here because this *longitudinal* or *axial* crack happens to run at right angles to all the *transverse* cracks of the Weald which are *mathematically demonstrated* by Mr. Hopkins to be igneous. In the next page Mantell says, 'Pursuing our course eastward, another *deep valley* occurs, through which is the romantic entrance to Hastings by the London road.' But he fails to tell us whether this 'deep valley' is an igneous or an aqueous *crack.* And when we pursue our course a little more eastward still, what are we to call the *longitudinal* or *axial*

The *axial* valley of the Rother.

valley of the Rother, with a waterslope of perhaps six times the size of its *transverse* neighbour the Cuckmere? It is impossible that Mantell should have perceived that his valley at Hastings was diluvial without also perceiving that the entire valley of the Rother, from Crowborough to Rye, is also diluvial, and that this valley, now to so great an extent alluvial flats, is washed by rain out of what was originally the very highest part of the Weald *hill*. Why then is he silent on the subject? And why are all the writers on the denudation of the Weald silent on the existence of the Rother and of its delta, Romney Marsh? Why, unless it be that the existence of these totally contradicts and overthrows their igneous crack theory?

Romney Marsh the delta of the Rother.

With regard to the early history of this delta of the Rother, Holinshed talks of 'Romneie Marsh, which in old time was called Romania or Romanorum Insula.' Mr. Holloway says that Romney is the Saxon translation of this—ea being island. Dugdale referring to its embankment says, 'That it was therefore a work of the Romans, whilst they were masters here, as it is the opinion of some learned men, so do I thereof make no doubt;' and he quotes Tacitus 'that the Britons complained that the Romans wore out and consumed their bodies and hands 'in sylvis et paludibus emuniendis.' Dugdale says that Romney Marsh was 'more anciently secured from inundations

of the sea than any other part of this realm, as may seem by the laws and constitutions for regulating its repair, which have been long ago made the rule and standard whereunto all other marshes and fens in the nation were to conform.'

In the Saxon times the grants of marsh land to the Church are of constant occurrence. Mr. Holloway gives one of the earliest, A.D. 774. 'In nomine Jesu, Salvatoris mundi, &c., Ego Offa Rex totius Angliorum patriæ, do et concedo Janibert Archiep. ad Ecclesiam Christi, partem terræ trium aratorum quod Cantianite dicitur Three Sulinge in occidentali parte regionis quæ dicitur Mersware, ubi nominatur ad Lyden, et hujus terræ sunt hæc territoria. Mare in oriente, in aquilone et ab austro terra regis Edwy, nominant Dengemere, usque ad lapidem appositam in ultimo terræ, et in occidente et aquilone confinia regni ad Bleechinge.' This seems to place Lydd (*Query* from Littus) on the shore, though it is now nearly three miles from the shore, and where Dungeness lighthouse stands now the sea probably ranged then.

Leases were granted by Gaufridus, Prior of Christ Church, Canterbury, about 1100 (a century and a half before the commission of Henry de Bathe) from which Sumner gives the following: 'et debent wallas* custodire et defendere contra friscam et salsam, et

* Throughout Romney Marsh the embankments are called *walls*, doubtless the lineal descendants of the Roman vallum.

quoties opus fuerit eas reparare et firmas facere secundum legem et consuetudinem marisci.'

In the days of 'our Henrys and our Edwards' scarcely a year passed without commissions concerning the embankments of Romney Marsh, and commissions for other marshes were to act 'according to the laws of Romne marsh.'

The ordinance of Henry de Bathe, constituted at Romney, A.D. 1258, is the Magna Charta of marsh defence throughout England. But it alludes to the *ancient* laws and customs of Romney Marsh thereanent; and indeed it seems founded entirely on these 'antiquas et approbatas consuetudines.'

To come to modern times and to physical causes, the natives of this delta to a man will tell you that the land was 'left by the sea,' and they talk of the sea *receding*. But if the sea receded here it would recede at Folkestone, Hastings, and Beachy Head, where on the contrary it advances on the land. But if 'left by the sea' means washed up by the sea, nothing can be more clear than the distinction between what is washed up by the sea and what is washed down by the river. What the sea casts up here is simply shingle and sand, worth perhaps three farthings a year rent as pasture, and as for ploughing it no one but Ulysses would attempt it. But in the delta and the alluvial plain together there are 62,449 acres embanked and drained, which perhaps average above three pounds an acre rent. Now the whole of this

land has been brought down by rain and the river. Man has held more or less of these acres for the last 2000 years. When nature held this farm direct under the Almighty, I *imagine* that the river had three outlets, as is usual in deltas;* a main central trunk from Appledore to Romney, and two side outlets, one towards Hythe, and one towards Rye and Winchelsea. When the central Romney river overflowed its even self-built banks, the heaviest materials held in suspension were soonest dropped, and the plain formed sloped from the central river to the two side outlets, where the floodwater, together with the adjacent streams, escaped into the sea. Man, by embanking, has altered all this. There is now no longer any upward growth of the plain, or as it is here called 'swarving up.' On the contrary, as the water is let off by sluices through the beach at low water, the plain is exposed to denudation, and may probably be considerably lower now than it was in the time of the Romans. All that the river brings down is now forced directly into the sea. This causes a vast accumulation of sand at Rye harbour, and an extension of the delta there by deposition. Indeed it is not only that the embankment of '*derelict land*,' as it is called, goes on to this day, but it may almost be called compulsory. For instance, the corporation of Rye embanked marshes between 1833 and 1838, which they *wished*

Embankment of *new* land still goes on.

* See page 244.

to preserve as reservoirs of tidal water to scour the mouth of the harbour. But these marshes 'swarved up' so as only to be covered at the highest spring tides, and thus became useless as reservoirs for scouring. Here a present of land was forced on the corporation against its will by rain and rivers which from its nearness to the town is perhaps worth a rent of £5 or £6 per acre. About 1853, Lord H. Vane enclosed land on the great stone side of what was Romney harbour, and the corporation of Romney are in the act of enclosing now (written 1861) on the little stone side of this quod Cantianite dicitur 'swarved up' harbour. Vast accumulations of sand are going on outside the mouth of the Rother. On this foundation the river will deposit the richest land, and Rye will be left inland as Newenden (formerly Portus Anderida) has been left inland.

Only *mud* goes out to sea.

But however capacious the *mouth* of the sea it can only *swallow* the *finest* possible food, that which is held in suspension in water. All the rest which rain and rivers bring down the sea masticates on the shore, in the form of sand, shingle, and boulders; and of these the sea throws up a wall for the protection of deltas against itself. And most wonderful are the collections of beach from Fairlight Cliff to Rye Harbour, at Dengeness and at Hythe; and I imagine that of the flints which pervaded the enormous mass of chalk which once overarched the Weald *Hill*, some from the south side may at this

The chalk flints which covered the Weald *Hill*.

instant be denizens of the beaches from Dover to the Land's End. Some may have supported the foot of Julius Cæsar at his (much discussed) landing-place. Some may have been equally civil to William of Normandy at Pevensey, others to the third William in Torbay; while from the north side these flints still help to bed the valley of the Thames, and proudly support Queen Victoria, and all that shines so exquisitely in female form in Kensington Gardens and Hyde Park. Eastward at Dengeness some still silicify the pointed pyramid of the delta of the Rother. Westward I think that they probably bed the upper valley of the Itchen, from Bordean by Bramdean* and Tichborne to Winchester. For I think it probable that the ancient Itchen once took its source in the chalk above what is now 'the Wealden heights,' that is, the Forest Ridge of the Weald *Hill*, and that the dry valleylet from Froxfield by Stapley to Bordean is on the point of changing (as other valleylets have done) from the waterslope of the Itchen to the waterslope of the Arun.

The Itchen once rose on the Weald *Hill*.

The waterslope of the Arun is still robbing the waterslope of the Itchen.

We must not expect to find these flints on the surface of the Weald except as exceptions. When they walked their chalks, Crowborough beacon and the heights of the Forest Ridge were covered full

* Masses of chalk rubble may be found heaped among the gravel between Bordean and Bramdean, as if by floods, and quantities of the flints are partially rolled. The largest of these are selected for building.

fathom five, not only by kindred beds of their own long gone, such as the Horsted beds, but by the depth of the Weald clay, the upper and lower greensands and the gault. When as exceptions (as at Barcombe) flints are found on the surface of the Weald, they are angular, which proves the atmospheric denudation of the Weald. If the denudation had been marine the flints should be rolled pebbles.

Romney and Hythe *once* cinque ports.

Some may hesitate to believe the possibility of the advance of the land of the delta of the Rother into the sea, that it should be able to thrust out an enormous pyramidal cape into the sea at the very moment that the sea is advancing on the land on both sides of it, and tearing down the neighbouring cliffs of Folkestone, Hastings, and Beachy Head. Λιμήν is Greek for portus, Hythe Saxon for port. Some may doubt if the little inland hamlet Lympne was Ptolemy's καινὸς λιμήν or the Roman portus Lemanis, or portus novus, though it still has its Roman castle, its Roman road to Canterbury—Stone Street, and thence to London—Watling Street. Some may doubt that Limen was the ancient name of the Rother. Or that the Saxon Limenemouth meant either the mouth of the port or the mouth of the River Limen. But no one can doubt that Hythe and Romney, which are both inland now, were once Cinque Ports; and impossible as it may appear to

They *now* bear sheep not ships.

some, it is equally certain that within historical times all the harbours of the alluvial Rother have been 'swarved up,' and now bear sheep instead of ships.

Now 62,000 acres, worth perhaps £200,000 a year rent, are not formed by an igneous crack certainly. What did form them? Rain and rivers; and rain and rivers i forming them sent a million times 62,000 acres into the sea, which is quite enough to account for alluvial valleys and a delta, where once stood the highest part of the anticlinal ridge of the Weald *Hill*.

The alluvial plains of the Medway, and of the Great and Little Stour, have grown as rapidly as the delta of the Rother. And Portus Rutupensis, like the harbours of the delta, bears sheep not ships, in the form of 25,000 acres of rich pasture. These dry acres are formed by deposit from water. If they had been raised by subterranean fire, the beach on which the Romans built at Dover would also have been raised.

Suppose that we modestly estimate that the entire earth is covered each year with a yard of rain, and that, speaking loosely, this enormous body of water returns to the sea through the rivers. Every one must perceive that the nearer the mouth the more water the river has to discharge. The fall of water and consequent denudation on the hill-top are, as they would say, arithmetical,

there is no accumulation there. But the accumulation and aggregation of water and denudation are in a geometrical ratio as we proceed from the hill to the sea. The consequence is the cutting of the river channel below low water, a broad horizontal alluvial valley, with 'a lazy-flowing, mud-collecting (and mud-depositing) river.'

CHAPTER IV.

THE ST. LAWRENCE WILL RUN THROUGH RIDGES BY PONDING.

RIVERS MAY RUN THROUGH RIDGES OF HILLS BY PONDING, AS IN THE VALLEY OF ST. LAWRENCE. LYELL CONTRADICTS HIMSELF ON THIS SUBJECT. THE AMERICAN LAKES ARE BEING LAID *DRY* BY *RAIN*. THIS WILL HAPPEN WITHOUT ANY *APPARENT CHANGE*. TWO MINIATURE WEALD VALLEYS IN THE ISLE OF WIGHT. ORIGIN OF THE CHINES. ORIGIN OF THE NAME OF 'THE WEALD.' ANSWER TO LYELL'S QUESTION, 'AT WHAT PERIOD WAS THE WEALD VALLEY DENUDED?'

THE *hill* of the Weald and the *valley* of the St. Lawrence seem to have as little to do with each other theoretically, as practically they are far apart. Yet as each illustrates one of two modes in which nature drives her rivers *across* and *through* ridges of hills, I shall consider the two as *one* subject in *two* chapters.

Lyell writes of the valleys of the Weald *hill*: 'If these transverse hollows could be filled up, all the rivers, observes Mr. Conybeare, would be forced to take an easterly course, and to empty themselves into the sea by Romney Marsh and Pevensea Levels.' To this we may add that then,

and in that case, the Weald *would* be a valley with one lower outlet; and *if* we prolong our *ifs*, we may also prolong our valley.

For *if* the English Channel were filled up, and *if* the North and South Downs ran across it, and joined the chalk borders of the Seine, the waters of the Weald would help the Seine to drown Paris. And *if* Hampshire and the banks were high enough, and 'all the transverse hollows in France could be filled up,' the rain which falls on Nore Hill would run through the railroad tunnel above Dijon, and so by the Saone and Rhone to the Mediterranean. But τί εἴ οὔρανος ἐμπέσοι; this *if* appears to me inexpressibly childish, as also does one of Lyell's own *ifs* ('Principles')

If the high ground between the heads of Lake Superior and of the valley of the Mississippi were to sink 'by a series of successive subsidences,' the lake would be emptied into the Gulf of Mexico instead of the North Atlantic. 'If the event happened in a dry season, when the ordinary channels of the Mississippi and its tributaries are in a great degree empty, the inundation might not be considerable; but if in the flood season, a region capable of supporting a population of many millions might be suddenly submerged.' But Lyell forgets that the lake is filled by the rain and rivers of the high land, and that as the high land sank 'by a series of successive subsidences,' the

lake would gradually become a dry valley. But now, after having abused the *ifs* of others, I will have an *if* of my own, or rather in conjunction with Lyell. He himself shows us that this lake and all the American lakes are at this instant quietly in process of becoming dry valleys, without any violence, or any catastrophe, or any *cataclysm;* that's the word, because people would understand you if you used the word flood. In *direct contradiction* to his own theory that all valleys are formed by submarine denudation, he says ('Principles'), 'The falls of Niagara afford a magnificent example of the progressive excavation of a deep valley in a solid rock.' The cataract is now 165 feet in height: 'When it began to recede, it must have had nearly twice its present height.' Say 300 feet.

Rivers may run over and through ridges of hills by ponding, as in the valley of the St. Lawrence.

Lyell thinks that the river forms this gorge at the rate of one foot in a year, and would therefore have taken 35,000 years to form the present seven miles. Mr. Bakewell allows a yard a year, reducing the period to below 12,000 years. There are yet fifteen miles of gorge to make before the river begins to let off Lake Erie.

Now, here is a grand *if*. *If*, 50,000 years *after* this (don't laugh, there have been 50,000 50,000 years *before* this), Lyell, Martin, Hopkins, and Humboldt were to man a four-oar up the St. Lawrence, through this valley into the valleys which *were* the American lakes, how the whole crew would pride

themselves on their 'cross fractures,' and 'rectangular intersections of geodesic lines!'*

As Lake Superior would have been the main recipient of alluvium, they might perhaps find little to indicate that the lower valleys had ever been lakes. 'And how on earth,' says Mr. Hopkins, 'is Colonel Greenwood going to make this placid stream cut a channel through yonder limestone mountain ridge thirty miles in length?' Here Lyell, looking serious, says, 'To tell you the truth, gentlemen, 50,000 years ago I foretold in the seventh edition of my "Principles," page 202, that the river would do this.' 'Well,' says Mr. Hopkins, 'its *raa*ther late to contradict this now, but you must, because in your "Elements" you stood by me and my mathematical earthquakes in the Weald. And in the very "Principles" which you quote, you have ventured on mathematical earthquakes of your own, in Italy. Page 246 you have formed the course of the Anio on my igneo-mathematical plan.'

'The Anio flows through a deep irregular *fissure* or gorge in the Apennine limestone *which may have been caused by earthquakes*. In this deep narrow channel there existed many small lakes, three of which have been destroyed since the time of history,

* Herschel, 'Physical Geography,' 2nd edition, page 138, backs Hopkins in his mathematical earthquakes. As the crew is completed, I will put him in as a steerer, and scratch his name out of my immortals, whom I now limit to his father, Newton, Hutton, and Playfair.

by the erosive action of the torrent, the last of them having remained down to the sixth century of our era.'

Lyell contradicts himself on this subject.

And indeed it is hard to see, if the 'fissure or gorge' of the Niagara is of *aqueous* formation, why the 'fissure or gorge' of the Anio should be of *igneous* formation. For in both cases there is the same cause, a river, working on the same material, limestone, producing the same effect, levelling the dams of lakes.

'I shall not deny what I have printed,' said Lyell, 'nor can you; and you will allow, that, however often I have taken one side of this question, I have equally often taken the other. For instance, page 255; "If we ascend, for example, the valley through which the Dranse flows, we find that it consists of a succession of basins, one above the other; in each there is a wide expanse of flat alluvial lands, separated from the next basin by a *rocky gorge*, once evidently the barrier of a lake. The river has filled those lakes one after the other, and has partially cut through the barriers, which it is still gradually eroding to a greater depth. The examination of almost all valleys in mountainous districts affords similar proof of the obliteration of a series of lakes by the filling up of hollows, and the cutting through of rocky barriers, a process by which running water ever labours to produce a more uniform declivity."' 'There!' said Lyell, 'I am

right *either* way; for my sword cuts *both* ways.' In Mr. Hopkins's quick reply, the words were heard, 'better a sword should cut *only the right way*.' But Mr. Martin and Humboldt interposing, adjourned the debate to that day 50,000 years.

I have said that the denudation of the Weald and that of the valley of the St. Lawrence each illustrates one of two *opposite* ways in which nature works the *same* effect, namely, the driving rivers through ridges which cross their courses. It must be confessed, however, that to level and perfect the waterslope of the line of American lakes is a more difficult job than to make that of the Weald. For in the Weald the water has always worked from above, on soft materials, and with any number of streams, while the St. Lawrence has had, single-handed, an *up-hill* work, through the very hardest materials. It has had to fill the lakes before it could erode the lowest part of their brims.

But though water cannot flow *up* hill, it can by ponding flow *over* hills, and so cut channels *through* hills, and this, as Lyell says, is a very universal process in nature. This universal process is, however, directly opposed to the submarine theory.

The American lakes are being laid *dry* by *rain*.

Truth, if not always, is at least often paradoxical, and paradoxical as it may appear, it is nevertheless true, that *rain and rivers* are laying *dry* these, the largest bodies of fresh water in the world. And that by a double process also paradoxical. First,

by *filling* them with alluvium. Second, by *emptying* them by eroding their barriers.

With regard to the first cause, the filling them in, Lyell says, 'the streams which discharge their waters into Lake Superior are *several hundred* in number, without reckoning those of smaller size. On the northern side, which is encircled by primary mountains, the rivers sweep in many large boulders with smaller gravel and sand, chiefly composed of granite and trap rocks.' The more central deposits consist of 'finer mud' and 'adhesive clay.' With regard to the second cause, the emptying of the lakes by the erosion of their barriers, that this is going on is proved by parallel terraces, marking their former levels far above their present levels. A depth of fifty feet has been thus taken from the surface of Lake Superior, which is nearly 2,000 miles in circumference.

This will happen without *any apparent change.*

Yet this great *actual* change has been worked without *any apparent* change. That is, this vast bulk of water has passed through the single outlet at St. Mary's without causing the smallest symptom of flood at any former time, any more than the same process does at this instant. For the *increase* of the outflow is graduated by the *decrease* of the barrier, the *gradualness* of which we cannot even form a notion of. Indeed, the actual course of much more sudden changes than this is quite imperceptible to us. If a man never has an illness

from eight years old to eighty, he suffers much alteration in the time; yet at no one instant is he aware of the change which is continuously taking place in his organisation. With regard to the inorganic world, eternal gradual change is to finite beings like man the same as no change at all. So that when, for beneficent purposes, instead of eighty years, God ordains that geological causes should take 80,000 years to work their effects, man disbelieves that any change *is* occurring, or that any change *can* occur from such *insignificant* causes. The lake, however, will become dry land by the meeting of two opposite effects of the same, so thought *insignificant*, cause—rain. That is, by the raising of the bottom and sinking of the top of its waters. Man will then gain a *fertile* tract, whose area is nearly equal to that of England. And be the transmutation of water into land ever so quick, or ever so slow, no 'boundary question' can arise. During the operation and for ever, water will always *separate* Canada from America, John from Jonathan; may we not rather say that water will always *unite* them.

But this gift will be as subject to change as are all those which we receive from our Almighty Creator. The erosion of the barrier at St. Mary's will still continue. The vast alluvial flat will be diversified with hills and valleys, and all the sedimentary beds will be taken away by the same cause

which deposited them—rain—as is going on now in the ancient lakes of Auvergne. The St. Lawrence will then fill its estuary, and form an alluvial plain on it, and beyond this a delta will be protruded.

It is possible that the St. Lawrence may be still forming its estuary. Lyell says, that 'horizontal banks of recent shells appear at various heights, from ten to one hundred feet above high water mark, and inland beaches of sand and shingle, with similar shells, as also elevated limestone rocks, scooped out by the waves, and showing lines of lithodomous perforations—facts which indicate most clearly the successive upheaving of the land, since the sea was inhabited by the existing species of testacea.'

Suppose the land to have risen 100 feet above the level of the sea. This would have given a constant rapid fall from the river's mouth to the sea, and the river would thus gain the power of lowering its bed. While this was going on, no delta could be formed. And where rivers have estuaries instead of deltas, it may possibly in some cases be owing as much to the rise of land as to the wash of marine currents. In the case of the St. Lawrence, for instance, if a delta had been in formation before the land rose, as it rose the river must have cut a channel through the delta to the depth of 100 feet.

Two miniature Weald valleys in

There are two miniature Weald valleys in the Isle of Wight, which, like every other spot on earth,

the Isle of Wight.

witness to the transition of the earth into the sea. The north chalk, from the Needles to Culver Cliffs, is equivalent to the North Downs. The south chalk, St. Catherine's Hill, is equivalent to the South Downs. Doubtless this south chalk formerly ran east and west parallel to the north chalk; but it has been washed away by the sea. The loss of the two ends of this southern barrier allows the escape of the waterflow to the south. This is the origin of the *Chines;* and if any one wants to see nature beginning new valleys, these chines are very pretty examples of the operation. I think that the name is provincial for chin. Near Newhaven is a Chin Gap, of precisely the proper shape for the name.

Origin of the Chines and the name.

The wash of rain from the north of the south chalk formed the eastern part of the bed of drift which overlies the Wealden from Atherfield to Brixton (Bridestone) Bay; as the southern run of the north chalk has formed the western part of this bed, from Compton Bay to Brook Bay.

In all the geological sections and accounts of this district that I have seen, the north chalk is designated as vertical, the south chalk as horizontal. This is a great mistake. Equivalent parts of each have the same degree of dip; though the dip of the north chalk is to the north-west, and the dip of the south chalk to the south-east. On the top of the north range the chalk is nearly horizontal; but as we

descend to the north side and foot of the hill, the beds are vertical. On the top of the south range, the chalk has a gentle dip to the south-east; and but that the chalk which formerly clothed the south side and foot of this range has long been washed into the sea, the beds of it would have been vertical, as a matter of course; so would any tertiary beds beyond, with which, no doubt, this chalk was covered at its first elevation. If these beds were not vertical, we must suppose that the elevation of the anticlinal axis of the Wealden produced one mechanical effect on the north side and a contrary mechanical effect on the south side, which is absurd. We can *see* that the south-east dip of the lower cretaceous beds from Atherfield to beyond Rocken End, is equivalent to the north-west dip of these beds from Compton Grange towards Freshwater. If the upper bed of chalk did not dip also, we must suppose that it was deposited unconformably on the lower cretaceous beds, which is also absurd.

Origin of the name of 'the Weald.'

The now inland Newenden is supposed to be the ancient Portus Anderida by Henry of Huntingdon, Selden, Camden, Lambard, Dr. Plott, Dr. Harris, Dr. Hawtrey, and the great majority of authors. The British Andred and the Roman Silva Anderida gave rise to the Saxon Andredes *Weald*, which extended over the 'Forest Ridge' of the Weald Hill from Kent to Hampshire, and gave the name of the Weald to the district. I persuade myself that the

traces of this ancient Forest may still be seen as far west as Rotherfield in Hampshire, in the magnificent old pollards (polled) there, and in Alice Holt, and in the black rings of the charcoal burner. He was obliged to *poll* the trees to grow his coppice wood in the air, on account of the browsing of the deer and cattle.

Answer to Lyell's question, 'At what period was the Weald *valley* denuded?'

With regard to the question asked by Lyell, 'At what period was the Weald *valley* denuded?' the answer is, the period extends from the first moment that the tertiary strata were *rained on* to the present moment, and the period will be extended till the last grain of the Wealden region is deposited below the wave; nay, though it is a *bull*, till long after this; for when the Wealden strata are gone, the region will become an oolitic region; which, like all other regions, will be finally put under the sea. This process is going on now as rapidly as ever, and no causes have ever operated to denude the Weald which are not now at work every day and all day long. We have not yet sufficiently apprehended the true depth of the Pythagorean doctrine,

Omnia mutantur, nihil interit,

And—

Summa tamen omnia constant.

If the Weald had suffered denudation at some remote period, and had then remained the same,

it would be the only thing on this terraqueous globe which had not changed in the time.

> Nil equidem durare diu *sub imagine eadem*
> Crediderim.

The sea even changes places with the land as much as the land with the sea; and it does *not* roll now

> Such as creation's dawn beheld.

It rolls now where once wide continents spread their bosoms; and it once rolled where the Alps, the Andes, and the Himalaya now rear their snow-capped heads.

Beattie's lines are as full of philosophy as they are of poetry:

> Art, empire, earth to change are doomed,
> Earthquakes have raised to heaven the humble vale,
> And gulfs the mountain's mighty mass entombed,
> And where the Atlantic rolls wide continents have bloomed.

Nor even are the contents of its depths or its shallows the same for a single day. It is the region of perpetual deposit as the land is of perpetual denudation. In its fruitful womb new continents are for ever being generated; and these new continents it gives to man, as Aladdin did his new lamps, in exchange for old ones.

CHAPTER V.

LYELL ON THE VAL D'ARNO.

IF VALLEYS WERE WIDENED BY EROSION OF RIVER BANKS, THEIR SIDES WOULD NOT SLOPE, BUT MUST BE CLIFFS, WITH INTERVENING TABLE LAND. RIVERS CUT DEEP CHANNELS, RAIN MAKES WIDE VALLEYS. FLAT LAND MAY BE DENUDED. WATER MAY RUN WITHOUT A SLOPE OF LAND. NATURE *ENDEAVOURS* TO PREVENT DENUDATION BY *ROOTS*, NOT *LEAVES;* MAN BY TERRACES. ETERNAL CIRCLE OF CHANGES.

In chapter xlv., 'Principles,' Lyell makes up by far his best mixture of his various theories for the formation of valleys, since he there confines himself to rain and rivers. And with the exception that he lays too much stress on the erosion of their banks by rivers, with some trifling contradictions, the principles are here true principles. He talks of 'those *disintegrated* rocks, of which such enormous masses are swept down annually into the sea.' And he winds up with, 'by ploughing up thousands of square miles, and exposing a surface for part of the year to the action of the elements, we assist *the abrading force of rain*, and diminish the conservative effects of vegetation.'

This is all right. This is *subaerial* denudation, and very contrary to the *submarine* theory. Page

685, he inquires how far vegetation may 'retard the levelling effects of running water, which it cannot oppose, much less counterbalance. It is well known that a covering of herbage and shrubs may protect a loose soil from being carried away by rain, or even by the ordinary action of a river, and may prevent hills of loose sand from being blown away by wind; for the roots bind together the separate particles into a firm mass, and the leaves intercept the rain water, so that it dries up gradually, instead of flowing off in a mass, and with great velocity. The old Italian hydrographers make frequent mention of the increased degradation which has followed the clearing away of natural woods in several parts of Italy. A remarkable example was afforded in the upper Va D'Arno in Tuscany, on the removal of the woods clothing the steep declivities of the hills by which that valley is bounded. When the ancient forest laws were abolished by the Grand Duke Joseph, during the last century, a considerable tract of surface in the Cassentina (the Clausentinium of the Romans) was denuded, and immediately the quantity of sand and soil washed down into the Arno increased enormously. Frisi, alluding to such occurrences, observes that as soon as the bushes and plants were removed the waters flowed off more rapidly, and, in the *manner of floods, swept away the vegetable soil.* This effect of vegetation is of high interest to the geologist when he is considering the formation of these

valleys which have been principally due to the action of rivers. The spaces intervening between valleys, whether they are flat or ridgy, when covered with vegetation, may scarcely undergo the slightest waste, as the surface may be protected by the greensward of grass; and this may be renewed, in the manner before described, from elements derived from rain-water and the atmosphere. Hence, while the river is continually bearing down matter in the alluvial plain and undermining the cliffs on each side of every valley, the height of the intervening rising grounds may remain stationary.'

If valleys were widened by erosion of river banks, their sides would not *slope*, but must be *cliffs* with intervening *table*-land.

Observe the change of agents in forming valleys, in one short sentence. It begins with rain from above, and ends with the river '*undermining the cliffs*' from below; though it is evident that if valleys were formed by the undermining erosion of rivers, even in unrocky ground like our chalk, the sides would be precipitous '*cliffs*,' and the tops of intervening hills flat table-land; while the enlargement of such valleys could only take place by a constant calamitous succession of land-slips, in the same way that cliffs yield to the erosion of the sea.

Rivers may cut deep channels, rain makes wide valleys.

Rivers have the power to cut narrow channels or *ravines;* but they have very little power of widening these. Disintegration and the wash of rain widen these ravines into broad valleys. While this is going on, rivers convey to the sea what rain brings to them, which would otherwise pass out of the valleys more slowly by the wash of rain.

But rivers no more *make* the sediment which they carry than railroads *manufacture* the wares of which their traffic consists. The sediment carried by rivers is brought to them by rain from the entire surface of their *tributary ground*, or water-slope. Erosion of banks is an exceptional calamity. But heavy rain never happens but it loads the rivers with mud. Nay, it loads the along-shore waters of the sea with mud. These are matters of fact, not matters of opinion. We 'need no ghost' nor good eyes to ascertain them; all we need good is the umbrella and macintosh, to enable us *to go out and see.*

The Atlantic round Madeira, or the Mediterranean along Spain, France, and Italy, or the Ægean round the Isles of Greece, forms no exception: vidimus flavum each of them; or rather I have seen the Atlantic *red* instead of yellow at Madeira during heavy rain. It is astonishing how soon the sea clears. Still more astonishing that not a vestige of dirt, mud, earth, or clay remains on or *near* the shore of the grand recipient of all these. Ocean not only instantly swallows all, but licks the platter clean.

Flat land may be denuded.

But in the same page Lyell is 'overtaken by a violent thunderstorm,' near San Lorenzo in Spain; and 'I saw the whole surface, even the highest levels of some flat-topped hills, streaming with mud, while on every declivity the devastation of torrents was terrific. The peculiarities of the physiognomy

of the district were at once explained; and I was taught that in speculating on the *greater* effects which the direct action of rain may *once* have produced on certain parts of England, we need not revert to periods when the heat of the climate was *tropical.*'

Water may run without a slope of land.

But why the words '*greater*' and '*once*'? Why, if rain *once* denuded the surface in England, should it have ceased to do so *now*? Did it rain harder *once*? Or is the ground harder *now*? But however, cælo tonantem credidimus Jovem regnare (that Jove *rains*). And in a thunderstorm, Lyell believed that even flat ground may be denuded by *rain*, which he seemed to doubt in the first part of the page.

But I must say a word theoretically to those who may not have met with Lyell's practical proof. Most people are doggedly possessed of the idea *that water will not flow on land which has no slope.* But as rain falls from high Heaven, its only relief from rising on itself is to flow. Empty a decanter of water on the middle of the table. Does the water remain in the middle? Introduce a pipe of running water to the middle of a flat stone hall. The water flows all over the flat pavement, and finally escapes from the hall by every door. Why? Not because it flows without a fall, but because it rises on itself, and so makes a fall;

——— unda impellitur unda
Urgeturque prior venienti urgetque priorem.

As the tide flows *up* the bed of every river twice every day, perhaps for the space of 100 miles, at the rate of twenty miles an hour. Stop the pipe of supply and the hall will 'run dry;' continue the supply for ever, and a channel would be worn at each door, and from any two doors across the centre of the hall we should have one of Humboldt's 'great fissures,' or Messrs. Martin's and Hopkins' 'cross fractures.' Nature drains and denudes every flat on earth on this principle, a channel being cut *backward* from wherever the water can escape, with a celerity directly as the softness of the soil. These channels become small valleys, and so the flat no flat, but hill and dale.

We need no Jupiter Tonans, nor need we go to Spain, to see that flat land is denuded by rain. There is a clay field near this house, so flat that no eye could foretell which way the water would run off it. Yet every heavy rain, it discolours the whole of the stable pond with a copious yellow stream, through an exit in the bank. No one can doubt in this case that rain denudes the flat field and deposits in the pond.* I have seen this happen when the field was covered with an excellent crop of clover two years old. So that

* Possibly one of the benefits of underdraining is that, besides letting off water which would stagnate, in the operation the finer parts of soil are washed *in* instead of *out*, while the water which is discharged abstracts a comparatively small portion of the soil.

the strong soil was not only 'matted together' by *roots*, but the rain was 'broken in its fall' by the *leaves* and stalks, which really were close enough to the ground to effect this, operations which Lyell alludes to thus in finishing the page: 'In the torrid Zone the degradation of land is generally more rapid, but the waste is by no means proportioned to the superior quantity of rain, or the suddenness of its fall, the transporting power of water being counteracted by a greater luxuriance of vegetation. A geologist who is no stranger to tropical countries observes that the softer rocks would speedily be washed away in such regions if the numerous roots of plants were not matted together in such a manner as to produce considerable resistance to the destructive power of the rains. The parasitical and creeping plants also entwine in every possible direction, so as to render the forests nearly impervious, and the trees possess forms and leaves best calculated to shoot off the heavy rains, which, when they have been broken in their fall, are quickly absorbed by the ground beneath, or when thrown into the drainage depressions, give rise to furious torrents.' These are curious functions of the leaves. They first cause the rain to be 'quickly absorbed,' and then 'give rise to furious torrents.' But we may pass over small tributary contradictions when we are considering the four main channels of contradiction

by which Lyell forms valleys. And what a delightful change from the 'great fissure' system! At this moment all theories are left in the lurch, except disintegration and the wash of rain, and the question is how to prevent the whole surface soil being bodily washed away *by rain*, and this in England, Italy, Spain, and the tropics. Nay, in the tropics, but for the friendly intervention of *leaves*, not only the soil, but 'the softer *rocks* would speedily be washed away.'

Nature *endeavours* to prevent denudation by *roots*, not *leaves*;

With regard to the denudation of such 'steep declivities' as those of the Val D'Arno, nature endeavours to preserve the soil by the *roots* of woods, though Lyell has a hankering to make 'the *leaves* intercept the rain water, so that it dries up gradually, instead of flowing off in a mass and with great velocity,' and would persuade us that instead of the *roots* protecting the soil in tropical forests, 'the trees possess *forms* and *leaves* best calculated to shoot off the heavy rains, which, when they have been broken in their fall, are quickly absorbed by the ground beneath.'

The fall of rain from leaves is the *reverse* of conservative to the soil. Leaves collect the rain into infinitely larger masses than the natural raindrop, and mechanically tear up the soil. If you wish to *see* this fact, examine a road under the head of a tree; you will find only rough stones, because the finer material has been mechanically

ejected. If you wish to *hear* the fact, walk under a tree with an umbrella in heavy rain. The umbrella will tell you as plain as it can speak of the increased size of the drops.

man by terraces.

If man removes the roots of woods for cultivation, on 'steep declivities' like those of the Arno, his art preserves the soil by stone walls and terraces. Thousands, I might say millions, of miles of this terrace work clothe the hill-sides of the south, and this practical necessity affords the best possible practical proof of the truth of the theories which I advocate. When art has thus done her best greenly to flounce nature's garment to the highest, we often see above, long and deep ridges of grey, bald rock without a shrub. Yet, by the chemical action of the atmosphere and by the chemical and mechanical action of rain, this region, the picture of sterility in itself, is a constant source of the most fertile soil for the terraces of the hill-side below. That soil does not stop there. It does not stop in the valley below. It does not stop even in the depths of the sea. From these depths it will be re-elevated. 'The Spirit of God' moves *through* the depths as well as 'on the face of the waters,' and is present imo tollere de gradu, and each grain of soil which we have traced from the mountain-top to the ocean's depth will move for ever in the grand circle of changes contrived by an All-pervading Bene-

Eternal circle of changes.

ficence. *Circle of changes* I have called it, but the more proper term would be *circle of renovation.* And is the term *waste* quite proper for an action which converts the face of the barren precipice of limestone or granite into rich soil for the production of the most exquisite vegetation, which gives subsistence, and therefore existence, to the noblest of God's creatures ?

How exquisitely Ovid words the Pythagorean doctrine of perpetual change and renovation :

> Omnia mutantur; nihil interit. . .
> Hæc quoque non perstant quæ nos elementa vocamus.
> . . . *tamen omnia fiunt*
> *Ex ipsis et in ipsa cadunt.* . .*
> Nec species sua cuique manet, rerumque novatrix
> Ex aliis alias reparat natura figuras.
> Nec perit in tanto quidquam (mihi credite) mundo ;
> Sed variat faciemque novat; nascique vocatur
> Incipere esse aliud quam quod fuit ante, morique
> Desinere illud idem. . .

These are sublime doctrines as regards matter. So is the 'morte carent animæ' as regards the soul. 'There is,' however, 'but one step from the sublime to the ridiculous.' And, alas! that the profound philosophers who held these doctrines should have taken the one step beyond the transformation of matter to the ridiculous belief in the transmigration of souls.

* Protoplasm, carbonic acid, water, and ammonia.

CHAPTER VI.

LYELL ON THE VAL DEL BOVE.

LYELL'S *FIFTH* THEORY FORMS THE VAL DEL BOVE BY SUBSIDENCE. IT IS FORMED, LIKE ALL OTHER VALLEYS, BY RUNNING WATER. WHY VOLCANIC DISTRICTS HAVE WEAK SPRINGS AND DEEP *DRY* RAVINES.

Lyell's *fifth* theory forms the Val del Bove by subsidence.

Four different theories for the formation of valleys are not so many, but that Lyell must start a *fifth* for the formation of the great valley of Etna, the Val del Bove. He attributes its formation to *subsidence*. As he could not conveniently get the sea over Mount Etna, he forgets his submarine theory altogether, and simply fights against 'running water.'

'Principles,' page 396, he says: 'We cannot ascribe this valley to the action of running water; for if it had been excavated exclusively by that power, its depth would have increased in the descent; whereas, on the contrary, the precipices are most lofty at the upper extremity, and diminish gradually on approaching the lower region of the volcano.' Apply this argument to any other valley. Does the height of the sides of the valley of the Mississippi increase, from the Rocky Moun-

tains to the Gulf of Mexico? Does not the height of these sides vary in every part, without any reference whatever to the bed of the valley? The height of the *sides* of the valley, or their comparative height at different places, has nothing to do with the question. The question is, does the *bed* of the valley, independently of interruption from modern lava streams, slope continuously to the sea? as it does so, there is every presumption that this slope was graduated by water; and it would have required a miracle to have *subsided* in this form; consider the extent of the continuous descent of the Mississippi from the Rocky Mountains to the Gulf of Mexico, contrasted with the utter irregularity of the *sides* of the valley, and as Playfair remarks, it is as infinity to unity, that water must have graduated the descent; the *irregularity* of the *sides* of mountainous valleys, contrasted with the *regularity* of their *beds*, is the very fact which proves that valleys have been formed by the descent of water. For what other agent could have produced these marvellously regular slopes of boundless extent, in the midst of the most thoroughly irregular surfaces?

It is formed, like all other valleys, by running water.

Besides this, if the Val del Bove had *subsided*, it would have subsided bodily. But there are certain rocks, Finocchio, Lepra, Capra, and Musara, which, owing to their hardness, have resisted disintegration and the wash of rain, and stand abruptly

out of the bed of the valley. Of these rocks, Lyell, with much naïveté, remarks, 'Almost all the isolated masses in the Val del Bove, such as Capra, Musara, and others, are traversed by dikes, *and may, perhaps, have partly owed their preservation to that circumstance, if at least the action of occasional floods has been one of the destroying causes in the Val del Bove; for there is nothing which affords so much protection to a mass of strata against the undermining action of running water as a perpendicular dike of hard rock.*'

The precipitous sides of the valley are also scored throughout with an infinity of *projecting dikes*, or veins of injected lava. I call these as witnesses in my favour; for I do not think that subsidence would have left these projections, but disintegration and wash of rain would.

Lyell says of them: 'They consist of harder materials than the strata which they traverse, *and therefore waste away less rapidly under the influence of that repeated congelation and thawing to which the rocks in this zone of Etna are exposed.*' Now, though Lyell may not agree with me in thinking that these dikes prove the original formation of the valley *by waste*, he here allows and shows that the prolongation and enlargement of the valley are at this instant going on *by waste* precisely the same as they do in every other valley in the world. But though these dikes are *witnesses of*

the waste, they are by no means *measures* of it; for they are not only equally exposed with their softer neighbours to disintegrating causes, but, from their projection, they are infinitely more exposed to these disintegrating causes.

The head of every valley on a steep hill-side forms, and *must* form, 'an amphitheatre, surrounded on three sides with' banks, if not precipices, 'the loftiest being at the upper end, and the height gradually diminishing on both sides.' Lyell says this of the Val del Bove, as if it was extraordinary and peculiar to that valley. But *if* it were granted that this valley were formed by subsidence, is Lyell going to form *all the other valleys of Etna* by subsidence? or, if not, how have they been formed, except by the wash of rain? since they have confessedly never been under the sea.

Lyell, indeed, says 'that running water in general exerts no power on Etna, the rain which falls being immediately imbibed by the porous lavas; so that, vast as is the mountain, it feeds only a few small rivulets, and these even are dry throughout the greater portion of the year. The enormous rounded boulders, therefore, of felspar, porphyry, and basalt, a line of which can be traced from the sea from near Giardini, by Mascali and Zafarana, to the Val del Bove, would offer a perplexing problem to the geologist, if history had not preserved the memorials of a tremendous flood, which

happened in this district in the year 1755.' This was from snow melted by an eruption. But *is it possible* that Lyell *can* attribute the line of boulders to this one *historical accident?*

Why volcanic districts have weak springs and deep *dry* ravines.

In my opinion, the reason why volcanic districts have so few permanent springs, is the exact reverse of the reason given by Lyell. I think that the *lava* (I do not talk of cones of *cinders*) of these districts is generally so *un*-porous that all rain is instantly shot off in the form of surface flood water. Besides, I think that the sort of dome-like, pent-house form, in which the coatings of lava are successively laid over volcanic districts, has a tendency to shoot water *off* the surface, and prevent its soaking *in*. And hence the depth of the *dry* ravines, and the weakness of the springs. If 'the rain which falls were immediately absorbed by the porus lavas,' it would reappear in strong springs, streams, and rivers.

But besides that in his account of the Val del Bove we have just seen that Lyell refers to 'the action of the occasional floods,' a little after his first historical flood of 1755 he tells us of another historical flood in 1761. In this second historical flood, which rose from 'the fall of heavy rains, aided, probably, by the melting of snow,' '*sixty* of the inhabitants of Acicatena were killed, and many of their houses swept away.' I wonder how many *unhistorical floods* pass down the valleys of Etna

every year now, and how many millions *have* passed down them. I should *guess* that, while the snow is melting, streams must run from the head to the foot of Etna every year for perhaps a hundred successive days and nights. But, besides the effects of general aqueous causes, is Etna free from the effects of its own particular local watering-pot? — from the lava d'acqua? In describing Vesuvius, Lyell says, 'great floods of mud were as destructive as the lava itself—no uncommon occurrence during these catastrophes; for such is the *violence of rain* produced by the *evolutions of aqueous vapours, that torrents of water descend the cone* (no porousness helps it here), and becoming charged with impalpable volcanic dust, and rolling along loose ashes, acquire sufficient consistency to deserve their ordinary appellation of "aqueous lavas."

In ancient times, Herculaneum and Pompeii were both overwhelmed by these floods of mud, as in modern times were St. Sebastian and Massa, so suddenly as to suffocate seven persons. 'It will, therefore, happen very frequently, that towards the base of a volcanic cone alternations will be found of lava, *alluvium*, and showers of ashes.' Herculaneum is 'covered not only by showers of ashes, but by *alluviums* and streams of lava,' 'to a depth of nowhere less than 70, and in many places of 112 feet.'

Lyell says of Torre del Greco: 'It seems probable that the destruction of *three thousand* of its inhabitants in 1631, which some accounts attribute to boiling water, was principally due to one of those *alluvial* floods which we before mentioned.' But *alluvium* is not deposited anywhere without a corresponding denudation somewhere.

CHAPTER VII.

LYELL ON THE VALLEYS OF CALABRIA.

LYELL'S 'PRINCIPLES' *THE WORK OF THE AGE*, BUT IT HAS *ONE* SPOT. LYELL'S *SIXTH* THEORY OF THE FORMATION OF VALLEYS. LYELL'S SUBMARINE THEORY DOES NOT APPLY TO VOLCANIC DISTRICTS OR ISLANDS. 'FLOOD OF OUTBURST.'

LYELL writes of 'the earlier geologists' that they 'were singularly unconscious of the amount of their ignorance.' With regard to the formation of valleys, I should apply the words of this *illustrious* author to himself. And I should consider myself *sufficiently illustrious*, if my exertions could induce him to erase the *one spot* from '*the* great work of *this* age.' If not, the great work of *the next* age will be an expurgated edition of Lyell.

Lyell's 'Principles' *the work of the age*, but it has *one* spot.

In his account of the formation of the valleys of Calabria, Lyell is as completely in contradiction as usual to his own submarine theory in particular, and to his four (or *five*) theories in general. Indeed, I think that he should here be credited with a *sixth* theory; for he here joins fire and water in a most unholy alliance against the devoted region. And the mode of action of the allied forces is quite distinct from their mode of action in the Weald.

Lyell's *sixth* theory of the formation of valleys.

Chapter xxix., 'Principles,' he considers 'how earthquakes contribute to the formation of valleys.' But his earthquakes in Calabria are no longer 'mathematical earthquakes' like those of the Weald. He does not crack out 'great fissures,' forming a 'rectangular intersection of geodesic lines,' like Humboldt, or fractures, 'longitudinal and transverse,' like Messrs. Martin and Hopkins. He makes his regular approaches, indeed; but on a system quite different from that employed in the Weald. He saps with water, and then springs his subterranean mine.

With the Mediterranean on one side, and the Adriatic on the other, he surely throws away a chance for the employment of his own submarine plan. And with the crest of the Apennines between these two seas, what an inexhaustible field for fissures, cracks, and portages! But, no; earthquakes and the erosion theory become the sole and sovereign specific for valley-making here. When taken to be well shaken; that is, when water has undermined the cliff from below, an earthquake is to shake it down from above. The plan would be no great *improvement*, however. In 1783, 60,000 Calabrians fell wretched victims to *one* earthquake.*

* The great igneous authority, Humboldt, repeats the ancient vulgar error, that volcanoes are 'safety-valves' against earthquakes. The Calabrians—oh fortunati nimium!—are nearly surrounded by safety-valves—Vesuvius, Etna, Stromboli, and another in the Lipari Isles. Humboldt quotes Strabo for the *fact* that Sicily was much

And if Providence were to be so improvident as to allow Lyell to carry out his plan as a system, the consequences would be as disastrous to the land as to its unfortunate inhabitants; for instead of gently sloping hill and dale, we should have a chaos intersected by clefts enclosed by cliffs.

Lyell says (p. 466) that 'the formation of valleys by running water can never be understood if we consider the question independently of the agency of earthquakes. It must not be imagined that rivers only begin to act when a country is already elevated far above the level of the sea; for their action must of necessity be most powerful while land is *rising* or *sinking* by successive movements.'

Again he talks of 'that peculiar removing force required to form a regular system of deep and wide valleys; for *time*, which they are so unwilling to assume, is essential to the operation. Time must be allowed in the intervals between distinct convulsions for running water to clear away the ruins caused by landslips, otherwise the fallen masses will serve as buttresses, and prevent the succeeding

more shaken by earthquakes *before* it was divided from Italy! and *before* Etna was a volcano! The modern earthquake referred to above, disregarding these ancient *facts*, not only desolated Messina at the foot of Strabo's safety-valve, but destroyed the aged Prince of Scilla, with 1430 of his people, who had taken to their fishing-boats in the hope of safety; and Humboldt says '60,000 were destroyed in Sicily, in 1693,' in spite of their Etna, their Stromboli, and their separation from Italy.

earthquake from exerting its full power. The sides of the valley must be again cut away by the stream and made to form precipices and overhanging cliffs before the next shock can take effect.

'If a single convulsion of extreme violence should agitate at once an entire hydrographical basin, or if the shocks should follow each other too rapidly, the previously existing valleys would be annihilated instead of being modified and enlarged. Every stream might in that case be compelled to begin its operations anew, and to shape out new channels, instead of continuing to deepen and widen those already excavated. But if the subterranean movements have been intermittent, and if sufficient periods have always intervened between the severer shocks to allow the drainage of the country to be nearly restored to its original state, then are both the kind and degree of force supplied by which running water may hollow out valleys of any depth or size consistent with the elevation above the sea which the districts drained by them may have attained.'

Here, in direct contradiction to his own *submarine* system of forming valleys, Lyell accords the function to rivers. But it appears that the operation is much facilitated if from time to time the valleys are choked up by earthquakes; or if the previously existing valleys should be annihilated, and 'every stream compelled to begin its operations anew, and

to shape out new channels, instead of continuing to deepen and widen those already excavated.' Also that 'the action must of necessity be most powerful while the land is rising or sinking;' *why*, he neglects to inform us. Rivers can only cut valleys down to the level of the sea, and if the land is then *raised* the rivers may then deepen the valleys. This would give the rivers more to do, if that is to make them more 'powerful.' But how would a *sinking* make them more powerful? With submission, neither Lyell nor earthquakes are likely to throw light on the subject; and 'if we consider the question' as dependent on 'the agency of earthquakes,' 'the formation of valleys by running water can never be understood.' However, in the proper districts of earthquakes, in volcanic regions, Lyell is right to call in running water, or any agent to form his valleys. His own submarine theory will not apply to volcanic districts or islands, for their surfaces have been ejected over them when they were already above the sea; and they have been coated and recoated thousands of times by floods of melted rock, when they had long been sub dio. Yet the gradients of the river valleys and dry valleys, and the whole form of the ridges and furrows of the entire surface drainage of a volcanic region (say Madeira), are so precisely the same as those of any other mountainous district, that no eye can glance over the two, and doubt for an

Lyell's submarine theory does not apply to volcanic islands.

instant that the same cause caused the form of the drainage of both.

In Tenerife I have seen numberless cases of volcanic dikes which projected from the opposite sides of valleys, and ran across the streams in their beds at all angles; and sometimes four or five dikes close to each other, and not parallel. The direction of the water-courses is never altered by these dikes, as is asserted by Keith Johnston. A dike simply retards the deepening of the ravine where the dike is, and that part of the ravine which is above it. The part below it will be deepened precisely as if the dike did not exist. But the part above must wait for the lowering of the dike, and the deepening will then *go on backward;* that is, from the dike towards the hill. When a dike runs diagonally across the main ravine, it of course does the same with the minor ridges and furrows, with which rain has scored the entire surface of the sides of each ravine. These minor ravines, however, run 'right up and straight down,' regardless of the dike or Keith Johnston. This may be well seen from the aqueduct in the ravine north of Santa Cruz. We have only to look at a geological map to see the incorrectness of Keith Johnston's remark, that rivers change the direction of their courses with every change of geological strata. These valleys of Tenerife are almost all dry, except in rain. The beds of the upper parts are sheer rock, the middle parts wear

the appearance of *torrents of boulders*, the lower beds are *alluvial plains of boulders*, and opposite the mouths of these valleys are very commonly *deltas and bars of boulders*. Behind these bars, after each rain, large deposits of earth and sand are formed, which the people diligently collect. Where permanent streams exist, they are usually lost at a considerable distance above the mouths of the valleys; that is, except in rains, they percolate to the sea beneath the *alluvial plains, deltas, and bars of boulders*. From the sides, hundreds or thousands of torrents of boulders fall into these rivers of boulders. Sometimes these lateral shoots have formed barriers of boulders across the valley, behind which large beds of boulders and earth have accumulated, again to be thrust out by heavy longitudinal floods. In this case I imagine that the overwhelming force of what the French call the débâcle comes into play. I shall translate it by 'the flood of outburst.' This takes place usually on the breaking up of the ice in all northern rivers or of dams formed by avalanches; and in such cases credimus Jovem regnare. But without frost or snow, in all steep hollows and mountain torrents, the 'flood of outburst' is of constant occurrence. The paving blocks of the beds of torrents catch floating rubbish, large and small, and form temporary dams and lakes. Away goes a block, which deepens the outlet some feet. Rock after rock follows, dashing itself and

Flood or outburst.

its neighbours below into pieces a tenth part of their former size. A day or two after, we decide that the brawling streamlet, which seems to ask permission to steal through these fragments, never did, nor ever will, have power to move one of them. This 'flood of outburst' is sometimes taken advantage of by man. On precipitous mountain sides, where whole trees could by no means be got out, they are cut and split into logs for firewood, and pitched into the streamlet below, till they dam the water and flood themselves down.

Can anyone look at the valleys of Madeira and Tenerife, and not *see* that they are formed by the rush of water? and that the process is still going on as actively as ever? Can anyone stand on the central ridges of Madeira, and not *see* that they are crumbling beneath his foot? That every year must lower their height? Can anyone *see* the blue Atlantic at Funchal turned to blood-red by every rain, and not perceive that the beautiful island is gradually and annually melting into the sea? Though it is beneficently ordained that during this process, as it becomes less mountainous, and holds back more soil, every year it should become better adapted to the support of vegetable and animal existence.

These islands exemplify the *contrary* effects of the *contrary* causes—fire and water, and vividly portray the perpetual *contest* between the two powers which Lyell has united. They show us that rain, which

we consider only as a productive power, is the destroyer, the dissolver of continents; and that subterranean igneous action, which we consider only as a destructive power, is the producer, the replacer of continents. The cause which caused the valleys is in as full operation at this moment as ever it was. Indeed, valleys exist only in the dissolution of hills; that is, in the gradual and eternal wash by rain of the existent earth into the sea.

Resolutaque tellus
In liquidas rorescit aquas,

and

Tellus glomeratâ cogitur undâ,

are as true at this instant as in the time of Pythagoras, and as they have been, and will be (shall I say ?) evermore.

CHAPTER VIII.

TRAVELLING OF SEA BEACH.

PENINSULA OF GIENS. FLINTS FROM TORQUAY TO THE LAND'S END. PEBBLES OF ALL STRATA FROM GRANITE TO FLINT IN SOUTH COAST BEACHES. GROINS. LAW OF THE SUGAR-BASIN. SORTING AND SIZING OF SEA BEACH. BLOWN SAND. BOULDER CLAY. PORTLAND, A NATURAL GROIN WHICH CATCHES THE CHESIL BEACH. DOVER BUILT ON A BEACH 2,000 YEARS OLD. SUBMERGED FORESTS. EMBANKED LAND IS DENUDED. NORTHERN DRIFT ANCIENT SEA SHORES. ORIGIN OF THE DRUID SANDSTONE. THE BRIGHTON 'ELEPHANT BED,' AND POSSIBLE ORIGIN OF THE 'CRAG.'

Peninsula of Giens.

In the first edition in 1857 I published an account of two isthmuses formed by travelling beaches, which join the island of Giens to the land and make it a peninsula. I alter the account here and give an entire chapter to the subject, because I think that my views were wrong, and that it is a subject of vital importance in geology and wholly misunderstood by geologists.

Flints from Torquay to the Land's End.

I was converted thus: I spent the winter of 1857 at Torquay, and found flints on the shore. This surprised me, because though there are flints half way between Newton and Torquay, they are inland and in the water-slope of the Teign, and I determined to see how far west I could find flints on the shore.

I visited Slapton sands westward of Dartmouth, and both sides of Start Point, the shore between Plymouth breakwater and the Yealm, Looe, Swanpool and Gillans bean at Falmouth, the beach below the Lizard lighthouse, Gadsworth cove to the east of the Lizard and Kynance cove to the west of it, Looe pool below Helston, Mounts bay on both sides of Penzance, Lennen cove at the Land's End, and both sides of St. Ives and Hayle. This was as far as I went, and at all these places I found flints—at such places as Slapton sands and Looe pool myriads of tons.

Pebbles of all strata from granite to flint on south coast beaches.

It now occurred to me that if I found the flints of the east in the west, a fortiori I ought to find the pebbles of the west in the east, since the beaches of the south coast are *supposed** to travel eastward *with the tide*, and in all the beaches which I examined from Weymouth to Dover I found a mixture of pebbles of all strata from granite and trap up to flint. As a general rule the great proportion of pebbles on a sea beach are from local strata. Travelled pebbles are generally numerous directly as their hardness, since directly as their softness they are easily ground

* To show the utter and universal ignorance which prevails at this moment as to first causes in geology and physical geography, I may quote Herschell's 'Physical Geography,' 2nd edition, page 91. Here this greatest man of his day makes 'tide currents' 'deposit' 'the great shingle drift of Dungeness Point and the Chesil Bank!' although the top of the Chesil beach is 42 feet above the top of the tide.

into sand. The only limit to the travelling of boulders and pebbles is their being ground into sand, and the hardest pebbles, that is flint and quartz, are the greatest travellers. So that the general rule above is sometimes greatly modified or indeed quite reversed thus. Anyone taking a glance at the beach of St. Leonard's, which is on the lowest Wealden stratum and about midway from the chalk of the North and South Downs, would say that it was composed of flint, and the countless myriads of tons of flint there must have travelled at least from Folkestone on one side or from Beachy Head on the other. Indeed, take our six south coast counties, and I do not think that from a glance at the pebbles on the spot anyone would at first say whether he was at Helston in Cornwall, at Slapton sands in Devonshire, at the Chesil* beach in Dorsetshire, at Hurst Castle in Hampshire, at St. Leonard's in Sussex, or at Dover or Dungeness in Kent.

Groins.

On observing what are called *groins* the whole affair appeared clear. Where the land is low or the cliffs are of soft material it is common to protect them by *groins*, that is, lines of posts boarded running straight *across* the beach and decreasing in height from the land to the sea. These groins do not protect the land *immediately*, but through the *medium* of the beaches. That is, they prevent the travelling of the beaches, and it is very curious to

* Chesil is Saxon for pebble.

observe how very light a breeze, if it is along shore or oblique to it (even off shore), will cause the wave to break obliquely to the shore, and consequently will heap the beach down wind against the groin. When the wave falls parallel to the shore it forms the lower shore in ridge and furrow running straight across the shore to the sea. But as the wind blows the wave flows, and as the wave flows the beach goes, and in general the wave breaks *on* the shore obliquely. But it always recedes *from* the shore straight, consequently every pebble that is moved travels *along* the shore with the wind or at least with the wave. On all large beaches of shingle two or three terraces may in general be seen, owing to the movement of beach at the different high water marks at spring and neap tides, and also to the accidental differing height and power of the waves at high water, and on the same groin these terraces may often be seen to have been heaped while travelling in opposite directions, according as opposite winds have prevailed. It requires an oblique gale of wind at high water at the highest spring tide to smooth the entire beach.

Groins are generally *tied* by cross beams from the side of the greatest exposure to wind. These beams become permanently imbedded and hold the groins by *tension*. So that the greater the weight on the groin the greater the power which holds its ties, and the weight *against* the groin is thus most

ingeniously made *to hold itself up*. When the pebbles have risen as high as the groins they flow over the groins. But they never heap on the leeward side. On the contrary, the sea always digs deepest on the leeward side of the groins. For the oblique wave flows freely up the heaped windward side and over the groin and falls with impact on the unheaped leeward side and would undermine *props* of the groin. Thus the beach on the leeward side of a groin recedes from the sea by denudation, and the beach on the windward side of a groin advances into the sea by heaping, and the oblique wave is constantly at work to bring the line of beach parallel to itself.

Law of the sugar-basin.

Pack the sugar-basin, the large lumps below, the small ones above, and cover the whole with fine pounded sugar. This arrangement will remain for ever unless motion is given. Give motion; the entire packing is reversed; the pounded sugar goes to the bottom, the large lumps come to the top, because the small grains have a greater facility in passing downward between the large lumps than the large lumps have. From the sugar-basin reason, when the field has been well worked and harrowed, all the surface flints are above the surface. Abstract the motion and they have a tendency to sink, I think, as low as the bottom of the soil. From this sugar-basin reason, as the largest pebbles are always on the surface of the beach, they are the first to be

Sorting and sizing of sea beach.

struck by the wave, and they are rolled to the top of the beach, and this sugar-basin reason sifts, sorts, and sizes the beach on every sea-shore or lake-shore of the wide, wide world. In screening sand or gravel the largest grains or pebbles run down to the *lower* part of the surface. On the shore it is the upward stroke of the wave which places the largest pebbles on the *upper* part of the surface, and as extremes meet, the lightest floatage and the heaviest drift travel together up the shore in each flood tide, and are left together in a line to mark how far it ranged.

But the largest pebbles on the surface of the shore are not only exposed to the upward stroke of the wave. They are also exposed to the onward stroke of the oblique wave. The largest pebbles travel most quickly to leeward, and between all groins this diminishing of the pebbles from the leeward groin to the windward groin may be seen.

Blown sand.

Now, as the oblique wave travels *along* shore, but returns *straight*, there must be a constant passage of water *along shore* to leeward. This must be compensated by an under current *in the sea*, and though this under current would not carry shingle, it would carry those finest particles of sand which may be held in suspension, and I think that this is the cause of the accumulation of sand fine enough to blow, which is so common at the wind-

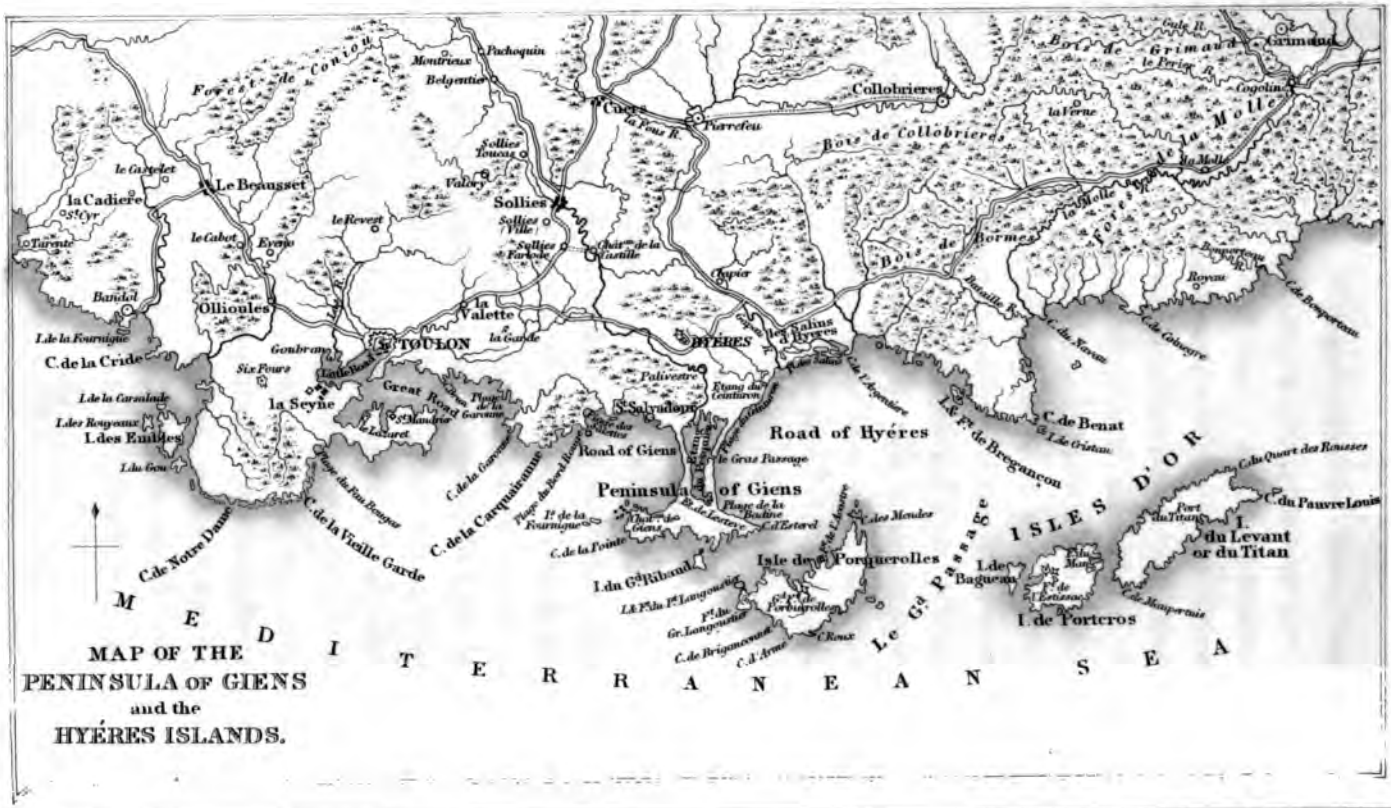
ward end of large beaches, and which may be observed at Bridport (Bride-port), the windward end of the Chesil beach, notwithstanding the constant export of countless tons to all parts of the world for the manufacture of 'Portland Cement.'

Boulder clay.

But besides these normal movements, some seas carry beach out for other seas to bring in again. Thus I was told by fishermen at Abbotsbury that their crab-pots were sometimes filled or buried by shingle at a considerable distance at sea, and at Slapton sands that smugglers dared not sink their tubs there for fear of losing them in that way. Quantities of beach are carried out too far to be washed in again. And in this way in the clays which are in deposit nearest to sea shores boulder clay is and ever has been in formation all over the world. This is the origin of the rounded pebble, the travelled pebble, the sand and the Druid-sandstone in our 'plastic clay *and sand*.'

Portland a natural groin which catches the Chesil beach.

Now, I think that the law of the sugar-basin and the laws of the groin apply universally to all beaches and that the peninsula of Giens and the peninsula of Portland may be viewed as natural groins. At St. Salvadour on the coast of France, opposite to Giens, I found what I conceive to be a raised beach. Raised beaches exist along our south coast, and I think that it is the shallows caused by the rising of the land which has allowed the accumulation of double beaches between Giens and the



MAP OF THE
PENINSULA OF GIENS
and the
HYÉRES ISLANDS.

Edwd Weller

land as well as between Portland and the land (Chesil beach and Smallmouth sands).*

Pebbles never accumulate where the water is deep and the cliff steep, not because they cannot *travel* there, but because they cannot *stop* there. A boulder lifted there travels with the wave almost as freely as the water which composes the wave. Boulders can no more accumulate where the water is deep and the cliff steep than soil can accumulate on the face of a precipice, though the soil is perpetually forming there from disintegration. It is the friction of a sloping shore and the constant tendency to be landed high and dry which

* It will be observed that I have attributed the formation of the Chesil beach and of all other beaches to the impact given to the wave by the wind, while all other writers, including even the great Herschel and Lyell, attribute their formation to currents or the tide. In the Geological Magazine for November, 1869, page 523, I wrote as follows: "I would wish to say a word as to the heaping of the beach which is formed by the 'natural groin.' Mr. Whitaker avoids the question. But he mentions 'the set of the current' *from west to east* three times. The shingle, he thinks, is carried by this current, since (page 435) the shingle is 'stopped in its *easterly* course,' and in page 436 he seems to form the shingle beach by 'the general set of the current.' Lyell, as quoted by Mr. Whitaker, attributes the heaping to 'meeting of tides,' 'a great eddy,' 'the tidal wave,' and 'the set of the tide in the narrow channel.' While Herschel (Physical Geography, 2nd edition, page 91) makes 'tide currents' deposit 'the great shingle drift of Dungeness Point and the Chesil Bank."

Let us for argument grant Mr. Whitaker's *assumed* current from west to east along our south coast, and let this current be of force sufficient to drive pebbles of the size of those at the Portland end of the Chesil beach, they would at least travel along the bottom of the

stops the boulder on his journey, and they *only stop when they have got out of the way of the sea.* They cannot rest within reach of the waves. A storm at a high spring tide may put them out of route for years, centuries, nay, thousands of years, and again set them at liberty.

Dover built on a beach 2,000 years old.

Speaking liberally, we know that part of the beach at Dover has been stationary for 2,000 years; since Lyon (page 149, vol. i.) says 'the Romans erected *some of their first buildings upon it* at this place and a part of the ruins have remained to our time,' and these banks must not only have been formed, but must have assumed a *permanent character* before they were built on by the Romans.

current. But even if they floated on the top of the current, how could they get to the top of the beach, which is 42 feet above the level of the water? So, if Lyell's and Herschel's tide had 'eddied' here, it must have flowed as high as the top of the beach, and even then it must have carried the pebbles on its surface to have placed them where they are. These philosophers would be the first to remind us of the rule that water can only find one level, and that it cannot rise above its source. And this rule entirely precludes the possibility of the beach being heaped by tides or currents. But rules are apt to have exceptions, and the exception here is that when impact is given to water it will itself rise, and it will raise other substances very much higher than its source. In art we see this in the ram which by impact sends water to the top of the house, though the ram and the source of the water may be much lower than the foundation of the house. In nature we see the exception in the effects of the impact given to the wave by the wind. It is then not tides or currents of water, but currents of air giving impact to the waves which have driven the drift to the top of the beach. Drayton gives this vera causa in 1613, 'by the south wind raysd.'—Note to the third edition.

From these times to the present day, and especially from the times of Edward the Confessor, William the Conqueror, Henry VII., and Henry VIII., the case has been perpetually litigated, engineers versus travelling beaches, or Act of Parliament against act of ocean. The engineer's art, however, has not been called on to prevent ocean from destroying its apparently most ephemeral land together with the the town on it, but to prevent ocean from consolidating its work to such a degree as to stop up the harbour. Lyon says (page 146) 'the houses at the foot of the high and almost perpendicular cliff, are considered by strangers in a perilous situation; but use has familiarised it to the inhabitants, and experience has taught them that there is not much danger to be apprehended by the falling of the chalk above them.' This *fact* is quite in accordance with the theories which I fight for. The sea undermining the foot of a cliff keeps it a precipice and induces heavy falls. Remove the action of the sea and atmospheric disintegration and denudation work most mildly in softening down the precipice, and the accumulation from its gradual decay is easily prevented. But for this it would long ago have formed a smooth slope of grass. But in parts now the foot both of the east cliff and west cliff is terraced and cut into somewhat smoky hanging gardens.

Every headland projecting from a line of coast

forms a boulder-parting or division of a boulder-flow, as the crest of a hill forms a water-parting or division of the rain-flow and soil-flow, and the foot of each headland is bare of beach as the crest of the hill is bare of soil. The ruins of the headland, however, furnish a constant supply of land boulders for the bay on each side, which accumulate there as soil accumulates in the valley.

If in the centre of the bay rain and rivers have denuded the land to the sea level, the sea cannot farther erode it except by first shovelling the whole beach on to the land and then eroding the ground on which the beach stood. Thus the hard headland while it faces the attack of the eternal eroder at the same time throws a shield of boulders before its softer neighbours.

Submerged forests.

Where the upright stems of trees, with their roots in their place as they grew, are found on the shore below high water mark, 'a catastrophe,' or 'a grand convulsion,' or 'a subsidence of the land,' or 'an oscillation of level' is inferred. Mantell calls these 'submerged forests,' or collections of stumps 'subterranean forests,' and he compares them to the silicified forest of the 'dirt-bed' of Portland, and the along-shore boatmen are quite angry if you will not allow that where the sea is now a forest was 'before the flood.' But such 'catastrophes' are, as I have stated in the Athenæum, simply the result of the most gradual

operation of rain, rivers and the sea. In former days the stream or the rain valley cuts its estuary far deeper even than low water mark, and forms what is called an arm of the sea. In later days the sea throws up a bank of shingle across the mouth of the deep-cut estuary, completely dams itself out and partially dams the streams in, though these often soak through the shingle at low water so as never to rise near the height of high water. Thousands of such cases exist in England. These sea beaches thrown up by storms frequently stand not only very much higher than the high water of the sea which throws them up, but the land behind them is often much lower than the high water of the sea, and thus, according to circumstances, peat, pasture or wood grows below the high water mark. The rapidity of the growth of alluvial deposit from periodical inland floods is then much increased. For all the alluvial wash of the entire valley or waterslope is here at once stopped short, none of it can percolate the shingle into the sea; deposit is rapidly accumulated on deposit, and rooted trees are found under peat, in peat, and above peat, not only on the shore outside the shingle-bank, but in cutting the sluices inside the shingle-bank, and by degrees the land which was below low water mark may be raised by alluvial deposit far above high water mark. When man appears on the scene, if fine alluvium plasters up

the shingle enough to hold back the water, it is a common practice to dig a trench a few feet into the shingle which lets the water flow off in a stream, or if circumstances admit, a trench is cut through the shingle and occasionally cleared. Then come sluices and iron piping through the shingle bank. The land drainage is *let* out at low water and the sea *kept* out at high water. Millions of acres of our best pasturage are held on this tenure. But when the streams are embanked and are let off to the sea so perfectly as to prevent their natural annual overflow, annual denudation of the old alluvium will take place, instead of deposit of new alluvium, and the land may again become denuded far below the usual tidal level.

Embanked land is denuded.

The natural progress of such shingle banks is inward, that is, landward. In this progress they include and preserve the stems and roots of any trees which are in their line of march, while the heads decay and fall. As the shingle bank travels inland the sea erodes the site on which the bank lately stood and exposes between high and low water the peat and the stems and roots which the shingle had covered. This may be seen at such places as Pevensey sluice, or at Pebblesham at the west end of St. Leonard's (and the *Ham* which the railroad traverses there is composed of *pebbles*), at Hastings opposite Mantell's 'diluvial valley.' In a minor way it may be seen in the bays of

Torbay. To the centre of the bay, as Torbay, the beach travels from each horn, from Berry head and from Hope's nose by the same wind. Hence the accumulation of beach at the centre of Paignton, and the very same force which has carved this bay out of the soft sandstone between the two hard limestone heads throws up this bar of protection. The Paignton beach travels from the Torquay or Hope's nose side to the north foot of Roundham Head. The Goodrington beach travels from the Brixham (Brides-ham) or Berry head side to the south foot of Roundham head, and walls are built, not to keep back the sea *water*, but the sea *land*. Through these accumulations of beach the streams are now passed artificially. In former ages before art let the water out at low water, marshes, bogs and peat have accumulated behind the beach. Peat is seen in front of it now below high water mark. In this peat at Torre Abbey the stumps of trees are seen.

As the prime agent in these movements, the wind, is the most changeable gentleman on earth, so are his works. They are constantly being placed, displaced and replaced; and in continuous gales boulders not only pass backward and forward, round headlands from one bay into another, but perform this countermarch constantly till they are ground into sand or till they get high and dry on a settled beach or into a settled line of travel.

We have here a vast, universal and eternal agency which is always at work, and which has been always at work, and which will be always at work on every shore throughout the globe, and which, without the aid of ice, or icebergs, or 'glacial epochs,' or 'waves of translation,' or 'great advancing waves from the north,' or other such *monstrous assumptions*,* is always forming accumulations of transported boulders here, of shingle there, and of sand in another place, and this simple cause has originated all those inland drifts which are entirely composed of boulders and water-worn pebbles with foreign pebbles among them. That is, all those drifts (and I include what is absurdly called 'northern drift') are simply ancient sea beaches; and as causes of the 'northern drift' the monstrous machinery and decorations which I have mentioned may be regarded and discarded velut ægri somnia.

Northern drift ancient sea shores.

As every part of the earth which is now above the sea has once or more than once been under the sea, so it is only natural that in every part of the earth we should find traces of the sea and of sea shores. Sea drift with the marvellous mixture of pebbles from granite and trap to the chalk flint, may be seen in six different positions within the

* Another source of *erratic* boulders on the shore is from the mouths of rivers, which, passing through the different inland strata, bring down specimen boulders from all of them.

narrow limits of my own county of Hampshire. The materials of this sea drift have been placed in these six different positions under circumstances most distinct, and in some cases at periods most distant one from the other. First and foremost, on our sea shores at this instant may be found mingled pebbles from every geological formation in England. Second, the same mixture is found in our raised beaches; and since the shore on which the Romans built at Dover is at the same level as the present shore, our raised beaches must be at the least 2,000 years old. Third, the same mixture of travelled pebbles is found in the gravels which bed our upper dry chalk valleys. These gravels are, indeed, almost entirely angular, or only slightly worn and *un*travelled. They are the residuum of denudation. That is, while the wash of rain cut the valley through the clay-capped chalk, the travelled pebbles of the tertiary clays were dropped in the bottom together with the untravelled angular secondary flint. Fourth, in the Druid sandstones of Froxfield, on the top of the clay-capped chalk hills of the Petersfield hangers, and in the pudding-stones of Bridestone lane, near Alton, I have found rounded pebbles of quartz mingled with pebbles of flint, and I should *guess* that as all conglomerates must have been formed on sea shores, *all* conglomerates will be found to be mixtures of *travelled* pebbles. These

Origin of the Druid sandstone.

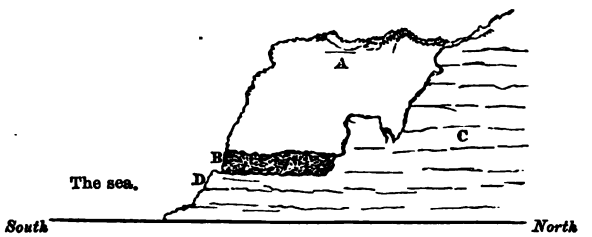
Druid sandstones and conglomerates have nothing to do with icebergs, nor have they themselves travelled, though their materials have. They are simply sand or pebbles of tertiary sea shores accidentally hardened into stone by water impregnated with iron, carbonate of lime, or flint. When they are on the bare chalk they also are the residuum of denudation, that is, these hard nodules remain after the soft clays have disappeared from the chalk by disintegration and the wash of rain. Fifth, over the entire surface of our ploughed land, whether of tertiary clay or of secondary chalk, the same mixture of travelled pebbles may be found. The clays have been deposited in the sea as a general rule farther out to sea than the sands, but in storms at high water sands and these pebbles have been washed into them. So that gravel-pits exist on our clay hill-tops entirely of rounded pebbles. When on the chalk, these pebbles must again be the residuum of denudation, that is, they remain after the clays which held them have disappeared by disintegration and the wash of rain; and Sixth, this marvellous mixture of travelled pebbles from granite and trap to the chalk flint is to be seen in the greensands of Woolmer Forest *under* the chalk. Have icebergs or the 'great advancing waves from the north,' or the 'waves of translation' driven this drift *under* the chalk? About as much as they have collected

the mixture of pebbles on our present sea-shores. The sands of Northern Germany and of European Russia have been deposited in shallow seas. What then can be more natural than that lines of travelled boulders, absurdly called northern drift, should remain where sea-shores were? That the wave has power to handle the largest block, even when most firmly fixed, witness the demolition and disappearance of our piers and breakwaters.

The Brighton 'Elephant Bed' rests on an ancient sea beach containing such a mixture of boulders. The Elephant bed itself is composed of unworn or slightly worn materials. Chalk rubble, loam, chalk flints and masses of Druid sandstone and conglomerates. These are sometimes cemented into what is called coombe rock by water containing carbonate of lime. Throughout the Elephant bed the remains of elephants, horses, deer and oxen are found. The shingle of the ancient beach below contains boulders of porphyry, granite and slate. The sand below the shingle contains bones of whales with sea shell fish of existing species. I consider this Elephant bed to be a land drift which reached the seashore after the beach was raised. Abstract the sea and there would be deposits of this sort around the whole of England. The sea sweeps the shore clear now of all that will float as muddy water. Mantell does not think so. He gives this engraving in the 'Wonders of Geology,' and supposes that

The Brighton 'Elephant Bed.'

when the ancient raised beach B was at the level of the sea the whole line of coast subsided to the depth



ELEVATED STRATA AND BEACH AT BRIGHTON, EAST OF KEMP TOWN.

A, Elephant bed; B, Ancient bed of Shingle; C, the Chalk; D, Terrace of Chalk beneath the ancient sea-beach.

1. (A), Chalk, rubble, loam, &c., obscurely stratified; this deposit, from its containing many teeth and bones of elephants, I have named the Elephant bed; it constitutes the upper three-fourths of the cliffs.
2. (B), Shingle, or sea beach and sand, several feet above high-water mark. This ancient shingle, which from the inroads of the sea extends in the cliffs beyond Kemp Town but a short distance inland, is constantly found beneath the loam and clay, several hundred yards North of the shore, in the Western part of Brighton. In wells sunk in the Western road, the shingle bed was reached at a depth of fifty-four feet.
3. (C), The undisturbed chalk, which forms a sloping cliff, inland, behind the Elephant bed (A), and shingle (B), passes under the latter, and appears as a terrace at the foot of the present cliffs (D).

at least of the present top of the Elephant bed A, and that the Elephant bed was deposited on the ancient beach under the sea, and that the whole has been raised again. I quite disagree. There has been no sinking since the formation of the ancient beach, but simply one rise to the small height above the sea which that beach stands at. This laid dry a vast extent of sea-bed. The action of the sea which had formerly kept the cliff C precipitous is removed. The cliff becomes '*a sloping cliff inland*,' and down its steep sides the Elephant bed has passed simply by the *wash of rain* and has been deposited

on the *dry* ancient beach. It is a *land* drift deposited on *land*, and therefore contains remains of *land* animals, consequently its materials are unworn or only slightly worn. But it is curious to consider the mixture of travelled materials, organic and inorganic, which meet in this land drift and the ancient and modern beaches below without the aid of ice or icebergs or waves of translation, but by the simple operations of rain, rivers and the sea.* The sea not only peremptorily refuses burial to our dead in her vast cemetery, but how often does she cast her own dead on to our shores, and thus we here find the largest animals of the land not mingled but in contact with the largest inhabitants of the deep. And it is curious to remark how Nature blows hot and blows cold at every turn. I do not mean that with one breath Nature blows the globe into a state of igneous fusion to please Leibnitz, and with the next breath into an icicle to please Agassiz. But observe the *contrary effects* which she makes to follow on each other from the *same causes*. I have mentioned the throwing up a protecting dam of beach at the centre of the bay by the very power which is scooping the bay out. Again, Nature has no sooner, by rain and rivers and the sea, cut the estuary deep below the level of the sea than with

* I have never seen the Crag of Norfolk and Suffolk, but from what I have read of it I should *guess* that it had originated from the same causes as 'the Elephant bed' has.

the very same workmen she fills up the cutting. She dams the sea out with its own beach and shovels the contents of the ever widening, ever lowering, ever lengthening valley into the estuary. Or in other cases, at her omnipotent will she makes the victorious land to follow the sea into its own regions, and protrudes a delta into it of thousands of square miles in extent. So in the case of Giens and of Portland, Nature has no sooner divided the islands from the land than by hoisting up the land she sets the same workman, the sea, whom she first employed to sever them from the land, to join them to the land again. What can be more contradictory or impossible than all this in theory? Yet in practice *it has* taken place for ever all over the world and *is* taking place all over the world now.

CHAPTER IX.

SEDGWICK'S DOCTRINE THAT DENUDATION IS ONLY ON LINES.

AQUEOUS DENUDATION IS UNIVERSAL, AND IS NOT CONFINED ONLY TO LINES OF TORRENTS AND RIVERS. THE BEDS OF GLACIERS SUFFER DENUDATION. LAND COVERED BY ETERNAL SNOW SUFFERS DENUDATION. CAUSE OF THE DESCENT OF GLACIERS. THAT ICE AND SNOW *MUST* ACCUMULATE AT THE POLES IS FALLACIOUS. MOUNTAINS WHILE RISING MAY BE DECREASING IN HEIGHT. AERIAL DENUDATION AND DEPOSIT.

Aqueous denudation is universal, and is not confined only to the lines of torrents and rivers.

ACCORDING to Professor Sedgwick (Lyell's 'Principles,' p. 684), 'torrents and rivers act upon lines only,' while vegetable growth and deposit, 'the antagonistic power' to 'the spoliation and waste caused by running water on the land,' are universal. But the area of aqueous denudation, or wash of rain, is still more universal than the area of vegetation. The disintegration of the barest rocks and precipices, of the barest mountain ridges, beyond the pale of vegetation, is washed by rain to the plant-clothed hill-side below. Nay, even from the mountain-top clad with eternal snow, the descent of this *en masse*, the avalanche and the glacier bring down débris with them to be disintegrated below. Indeed, glaciers bring down their huge quota ready ground

for exportation by the torrents which they generate. According to Saussure, four of these main channels, or trunk lines of denudation, are continuous from the top of Mont Blanc, and from these the débris of 'the monarch of mountains' are traced for great distances.

The beds of glaciers suffer denudation.

That the beds of the valleys of glaciers suffer denudation like those of other valleys, I think we may infer for two reasons. First, the grooves or lines *scratched* on the sides of the valleys by the passage of the glaciers are discovered far above their present level. Next, if this were not so, there would be an abrupt break or step from the glacier valley to the valley in prolongation of it.

Besides the *moraines* or heaps of *undigested* detritus deposited by glaciers at their lowest ends, the streams which issue from them are always *loaded with mud.* These streams are flooded in the spring and summer, when the snows melt, to such a degree that, Saussure says, they raise the level of the Lake of Geneva six feet in that season. There is a common belief that the waters of the Rhone pass through the lake without mingling with it. The river, however, enters the lake as muddy as possible, and leaves it as pellucid as possible. Perfectly clear water reflects the colour of the sky. And the waters of the lake and of the sea are as blue as the sky above them *in clear weather;* but in cloudy weather they are lead-colour.

Land covered by eternal snow suffers denudation.

The same argument will prove that the parts of mountains covered with perpetual snow suffer aqueous denudation precisely the same as all other parts of the earth. For if not, along the lower line of snow we should find terraces the reverse of those of Glen Roy, and similar to some which I shall mention in the next chapter; that is, the terraces would be above the denuded parts instead of below them. Summer rains, and the melting of snow by summer suns, percolate the snow, and what does not enter the ground runs off it, and denudes it the same as if there were no snow. But it is a fallacy to suppose that if a 'glacial epoch' had ever existed, a greater denudation would have gone on than now goes on by rain and rivers.

Cause of the descent of glaciers.

The cause of the descent of glaciers is simply the pressure of snow from *above* their upper ends. Mr. Hopkins ('Philosophical Magazine,' October 1859) is as unfortunate here with his glacial mathematics as he is in the Weald with his igneous mathematics. He talks of 'the tendency of such *an enormous weight of ice* to descend down a plane even of very small inclination;' and he mentions slopes 'at inclinations sometimes not exceeding 2° or 3°,' and he assures us twice over, that his conclusions 'were as certain as that of the parallelogram of forces, and no theory which contradicted them could possibly be true.' Very much so.

But then, no doubt, it equally as true is

that '*an enormous weight of ice*' can no more slide down a slight incline than a small weight of ice can. Or *if* it can, perhaps the mathematician will tell us *why* it can. And on slopes of two or three degrees, and on all the slopes of the lower ends of glaciers, solids large or small (and among them ice) would rest motionless. If a glacier could be extracted from its valley, the valley would be instantly filled again by the fall of the snow from *above* into it, which snow was before supported by the upper end of the glacier. It is only the pressure of this snow *from above*, which pushes the glacier down; abstract this pressure *from above*, that is, let all the snow be abstracted from Mont Blanc, and let no more snow fall, every glacier would cease *instantly* to move downward. They would retreat upward by melting, and would finally disappear; even above the former snow-line, they would melt in summer suns. But as snow constantly does fall on Mont Blanc, and as it cannot melt there in the same proportion as it falls, it would constantly accumulate there unless it was constantly shoving the glaciers down towards the sea, as rain is constantly shoving the whole surface of the earth down towards the sea. There is no tension from below. On the contrary, what is below waits for a vast pressure from above to set it in motion. Owing to the friction of the bed of the valley, the central ice yields most easily to *the pressure from above*, and

travels most quickly. This principle obtains also in rivers, though water is neither viscous nor brittle. But Professor Forbes is unfortunate in calling ice (one of the most brittle things we know), viscous. A glacier travels at different rates in different parts, or alters its form to the form of the valley on the same principle that holds in the ice-house, that is, by being pounded to atoms and freezing solid again. This results from extreme brittleness, the very reverse of viscousness. I have seen water frozen solid in small holes on the top of a Druid sandstone here. The ice, unable to burst the stone, may be said to have burst itself. That is, it rose in the centre like a bull's-eye, and the rays of fraction from the centre were so numerous as to give a white appearance to the ice. It has been said that (although water expands in freezing) ice contracts by cold. If so, such globes should become loose in their matrixes, which they do not.

That ice and snow *must* increase at the poles is fallacious.

Though ice and snow perpetually surround the two poles, it is not the *same* ice and snow, any more than the snow on the mountain top or the water in the river continues the same. And the idea that ice and snow *must* increase at the poles is fallacious. Every year thousands of enormous mountains, we might say *continents*, of ice (all bearing mud, earth, and stones) float off, and are melted in more temperate latitudes. The causes of increase or decrease of snow which *may* occur at the poles, are

shown by a magnificent theory of the illustrious Lyell.

Mountains while rising may be decreasing in height.

It does not follow that while mountains are rising they are increasing in height. They may be decreasing in height. Suppose the Alps to have been rising six inches in a century for myriads of years; if their denudation has been seven inches in a century, they have been decreasing in height.

It is true that the *direct* action in waste and denudation of torrents and rivers is on lines only; and were it not for the atmospheric disintegration and the *lateral* wash of rain this their *direct* action would only cut ravines and channels to the sea, and the sides of all valleys, instead of sloping, would be *cliffs;* that is, where a spring issues high up the mountain side, it will cut a deep ravine with precipitous *cliffs*, and the deeper it cuts, the more springs it will lay open. But what widens this ravine into a broad valley with gently sloping sides? The *lateral* wash of rain into the *longitudinal* valley. And what forms the broad valley, even *where there is no river at the bottom?* or within many miles? The *longitudinal* scooping power of the concentrated wash of rain, which in no respect differs from that of the torrent, except in its being a hundred fold more powerful than the torrent. It is indeed intermittent; so is the real scooping force of the torrent, for torrents only really excavate *when swollen by rain.* A torrent swollen by rain to

perhaps twenty times the volume of its usual spring water, and hurling fragments of rocks along of all sizes, is, in point of excavating and destructive power, as much more formidable than its usual self as a shotted gun is more formidable than an unshotted gun. Horace describes this well :—

cetera fluminis
Ritu feruntur, nunc medio aequore
Cum pace delabentis Etruscum
In mare, nunc lapides adesos
Stirpesque raptas et pecus et domos
Volventis una non sine montium
Clamore vicinaeque silvae,
Cum fera diluvies quietos
Irritat amnes.

We never *see* the clear torrent set its rocky ammunition in movement, though the shape of this ammunition tells us how often, and for what distances, it has been projected. But when the torrent is turbid with the wash of rain, we can *hear* its huge cannon balls rattling down, and grinding each other and their rocky bed and banks, till what has started from the mountain's brow as a huge rock arrives at the sea in the form of pebbles or of sand. For although, as the *flood of rain* subsides, *the flow of boulder stones* ceases, this is only for a time; each rain sets them on a stage on their journey, as, in lower levels and gentler gradients, will be seen of soil, and the more minute particles formed by disintegration and vegetable chemistry.

And it is not only that districts of rocks are

amply supplied with this ammunition which districts of softer subsoil are without; but as rocky subsoils have little power to admit rain by absorption, it agglomerates in the ravines which it finds ready loaded to the muzzle with loose rocks and boulders. And thus the longitudinal cutting of ravines proceeds in rocky mountains perhaps as rapidly as in softer subsoils. But the widening of these longitudinal ravines into broad valleys by disintegration and the lateral wash of rain is a process *infinitely slow* in comparison to what takes place in districts of softer subsoils.

But as sure as dry land stands betwixt high heaven and the sea, the waters of heaven will wash it into the sea. And whether the dry land be of soft or of hard material simply makes the difference of the comparative time required for the operation. In soft and porous subsoils, as the tertiary and chalk, though nature does not make so much fuss about the affair, she proceeds equally surely.

The top of the same Hampshire hill, which may be chalk capped with tertiary strata, is on one side moving to the German Ocean, through the medium of the Thames, and on the other side to the English Channel, by the Itchen, forming one of Humboldt's 'fissures,' or Mr. Hopkins's 'fractures.' From all sides of the tops of these hills, and from all sides of every height on the globe, there are *dry river beds*, sine flumine valles, down which soil flows

whenever rain is heavy enough to *run;* and all the infinite ramifications of these *dry rivers*, or ravines, or gorges, or gullets, or coombs, or chines, or bottoms, or vales, or dales, or deans, or lavants (*qu.* from labens), by whatever name they or any parts of them are locally called, all have descents graduated by water, and outlets to the running rivers (if not to the sea), without any abrupt junction of the lower ends of the dry valleys with the upper ends of the river valleys; and no drop of rain *runs* an inch on the surface of the earth without, as far as it goes, setting some soil forward on its road to the sea, and it won't run back again. No return tickets are given. It will wait there, and go on by the nex-*t-rain*. The very soil on which we tread, and which we cultivate, may be said to be on its road from the hill to the sea. Soil which is the disintegration or detritus of rocks (I use the term rocks in the wide geological sense) is in perpetual formation over the whole surface of the earth; and from the whole surface of the earth it is in perpetual movement, by the wash of rain, to the bottom of the sea.

This paragraph was scarcely printed in the second edition of the 'Tree-lifter,' before I had an opportunity of *seeing the surface water* flow from the two sides of Filmere Hill, as I have *supposed* the *soil* to do. Frost set in a day or two before Christmas, 1853, and a great quantity of snow fell.

In the night of Friday, the 6th of January, 1854, a rapid thaw began, with heavy rain. I walked from Rotherfield to Brookwood on Saturday. Owing to the hard frost the ground absorbed no water. It stood on the high road at East Tisted more than a foot deep, *nature's* gradient being dammed up by the cross road of *man*. Over this, the water flowed into *the Lavant*, from Farringdon, by Chawton and Maiden Lane, to the East of Alton, into the Wey and Thames. In following the high road from Tisted up the north-east side of Filmere Hill, I saw a continuous stream along the valley, running from near Ashen Wood. Where the valley was crossed by the new enclosures of West Tisted Common, the water was ponded back into lakes till it flowed over the small banks on which these fences stand. And (risum teneatis amici ?) if left to nature, precisely the same processes of filling *up* these lakes and cutting *down* their barriers would go on as have been described in the ancient lakes of Auvergne and in the valley of the St. Lawrence.

On descending the south-west side of Filmere Hill, I came to a stream below the Horse-shoes, which continued along the Dean to Bramdean, through *the Lavant*, between there and Cheriton, to Tichborne and Southampton. The streams of these two usually dry trunk valleys were joined by very strong streams from their usually dry branch valleys.

In such a case, where the surface of the ground

is frozen hard, one would suppose that very little of the soil would be *washed* away; yet whenever snow is drifted, be the ground ever so hard frozen, a great quantity of soil is drifted with it. 'White as the driven snow,' is an expression as trite as it is poetical. But as the driven snow melts, its surface becomes anything rather than white. The melting snow percolates through itself in the form of water, and the whole of the soil which is mingled with its entire bulk, is gradually accumulated on the surface, giving the drift the appearance of soil rather than of snow. And when the drift has entirely melted, a residuum of earth is deposited on the ground. If this aerial denudation and deposit of soil take place in drifts, I think it probable that aqueous denudation may take place in rapid thaws, be the ground ever so hard frozen. In fact, neither wind nor water under any circumstances, ever travels empty-handed. That is, dust and detritus in dry weather take passage by wind, in wet weather by water.

Aerial denudation and deposit.

I once saw a remarkable example of aerial deposit under circumstances the most adverse to it. In an attempt to ascend Mont Blanc, before our arrival for the night at 'Saussure's house,' I counted in a rent, or crevasse, of a glacier which we passed, many *years* of snow. The top of each of these annual beds was clearly marked in black, and I think it quite probable that an aerial deposit takes place over the entire snowy surface of Mont Blanc.

I need not remark that this portage of soil by wind must take place in all frosts, independent of snow drifts. Though the *effect* of this widely-operating cause will not be so *apparent* as when its burthen 'violates the ingenuous snow.'

What is *driven* along the bottom by water (for instance, shingle) is arrested on the *near* side of any obstacle in the form of *drift*, but what is held in suspension *in a stream* is deposited on the farther side in the form of *alluvium*. And a comparatively small object, say a drifted tree grounded in a river, by causing a back-water or eddy, may form a huge alluvium or mudbank or island below it, which may change the course of the river. It is very curious to remark the huge drifts of snow which very slight objects will collect on their *leeward* sides. But as the wind, unlike the stream, is constantly shifting to every quarter of the heaven, any collection of soil deposited by wind, instead of being constantly added to, may be frequently despoiled.

There are, however, some places, as the tops of bare hills, which are constantly denuded by wind, and others, such as woods, which are constantly enriched by wind; and as they are free from aerial denudation, the soil of woods is more than compensated even for the crops taken from them by man.

A part of the products of vegetation may be said to be *stored* in the bodies of animals. And as carnivorous animals prey on the herbivorous, a part

even in carnivorous animals, but the longest lived animals and plants die, and their hardest parts decay; so that, on the average, the entire mass of a year's growth of all terrestrial vegetation may be considered as taken annually from *below* the surface and annually deposited afresh *above* the surface. Much of the organic or combustible part of this growth goes into the atmosphere in the form of gases, to be returned again to the earth in rain. Of the inorganic or incombustible part, or what would be the ashes of plants and animals if burnt, much is washed into the earth by rain, much ploughed in as manure, much washed into the sea with other soil. But doubtless much of this 'finely divided matter' is transported by wind; and although in bulk, this aerial deposit is a joke to aqueous deposit, its fertilising qualities are great; and as woods and parts covered with strong vegetation catch a great quantity of it, by comparison they are enriched, while surrounding lands are denuded, even supposing aqueous denudation and deposit the same in both.

So in dry windy weather, when cultivated lands are thoroughly cleansed and broken finely for sowing, great quantities, even of *soil*, change places by wind, by which exposed spots are impoverished, and sheltered spots enriched.

This denudation of *soil* is visible; so is the deposit of leaves. There are spots in which leaves are never allowed to rest, and others which every

year catch large quantities. Ponds fill up even in man's short existence, and must be emptied if they are intended to serve as ponds. This happens whether ponds have a run of a stream through them, or a run of rain into them, or art prevents any run at all into them. In the last case aerial deposit will fill them, chiefly with leaves. But in all cases aerial deposit forms a great item in filling ponds.

CHAPTER X.

LYELL ON NEW RAVINES, AND ON THE GANGES.

FORMATION OF NEW RAVINES. 'SUNK ROADS' THE EFFECT OF AQUEOUS DENUDATION LYELL ON THE GANGES. RAIN HAS LAID THE WHOLE SURFACE OF THE EARTH IN RIDGE AND FURROW. THE SOURCE OF THE VALLEY IS ALWAYS HIGHER UP THAN THE SOURCE OF THE RIVER. TERRACES FORMED BY HEDGES. RIVERS OUTLETS OF MUD AS WELL AS OF WATER. GOLD ALLUVIUMS. CHINA CLAY. EVERYTHING ON THE SURFACE OF THE EARTH WHICH IS NOT LIVING IS DECAYING.

Formation of new ravines.

A VERY slight difference in hardness of surface or thickness of vegetation at the brow of a hill may concentrate the wash of rain into a stream; this forms a channel, which is fed by rain from its sides. And though all possible *natural* accidents of this sort might have been supposed to have taken place long ago in all but volcanic or newly raised regions, Lyell, quoting Sir T. D. Lauder's account of the great floods in Morayshire, August, 1829, says, 'Some *new ravines* were formed on the sides of mountains where no streams had previously flowed, and ancient river-channels which had never been filled from time immemorial gave passage to a copious flood.'

And again, Lyell, in giving an account of the formation of *new ravines* by heavy rains on the 28th of August, 1826, in the White Mountains in

New Hampshire says, 'The natural excavations commenced generally in a trench a few yards in depth and a few rods in width, and descended the mountains, widening and deepening till they became vast chasms.' This was the effect of *one* continuous heavy rain.

And in the present day we may see ravines begun by the accidental results of many operations of *man*. A hedge or ditch, a pathway or waggon-way, may commence the furrow on the mountain's brow, nay, even on downs which are covered with the closest greensward; and how many of our bye-roads and lanes become ravines!

'Sunk roads' the effect of aqueous denudation.

Indeed, as the long conduits whose gradients are laid by the wash of rain very generally become the roads or lines of traffic of man, so, *vice versâ*, the roads or lines of traffic of man, on or near declivities, very generally become conduits for the wash of rain. Hence our '*hollow ways*,' '*sunk lanes*,' and '*sunk roads*.' Hollow ways are so common as to give their name to men as well as to places. In fact, the moment roads or lanes leave the line of the valley, the moment they cross the hills from one valley to the other, that moment they become more or less *sunk roads*. And this 'more or less' depends on the steepness of the hills, without reference to comparative hardness: that is, the steeper the hill, the deeper the sinking of the road. The reason is, that roads on declivities are channels for

the wash of rain, and they partake of the nature of narrow valleys or ravines. In proportion as the surface of declivities is hard and unporous, the wash of rain and its power accumulate; so that, although declivities whose surfaces are soft are from this reason more easily abraded, by their porousness, which is generally a consequence of their softness, they are to a certain extent protected from denudation. That a foundation of the hardest rock will not support these modern gangways of man, witness the high *cliffs* on the sides of each Devonshire sunk lane.

Where the subsoil is soft, as chalk, instead of cliffs, the banks *mutter away*, and shelve off, and where trees or coppice wood grow, have an overhanging coping of roots and earth.

When a road runs horizontally along the side of a hill its upper side is loaded and its lower side denuded.

When a road follows the centre of a dry upper valley with a fence on each side, it very generally becomes '*sunk*.' And this appearance is increased by the fences stopping the wash of soil to the centre of the valley, and so *raising* the ground on each side of the road.

But no road running along the top of a ridge or hog's-back ever becomes '*sunk*.'

The deposit from the wash of rain on each side of all *level* roads is soon covered with growth; it then catches the dust or aerial deposit, and unless

the pickaxe and shovel are constantly at work the drainage of the road is soon choked up.

In comparison to the broad waste from the wash of rain the waste by the *direct* action of rivers may be reckoned as nothing; and even this waste by the direct action of rivers takes place, I might say, *entirely* when they are flooded by rain. The real main geological work of rivers is *indirect;* that is, the carrying off the traffic brought to them by the wash of rain; and they carry this mighty traffic for the entire terrestrial surface of the globe; at least their channels do. And the channels of most rivers would exist whether the rivers existed or not, as in the south you constantly see river beds dry or almost dry, except when filled by the superficial run of rain or the thawing of mountain snow; and the size of the channels of all torrents and rivers (except in alluvial parts, for a reason which is given in chapter xv.) is in proportion to the heavy floods of rain which occasionally rush through them, not to the comparatively small volume of spring water which always flows down them.

Lyell on the Ganges.

Lyell, quoting Mr. Everest, calculates that in *the rainy season* (four months) the *flooded* Ganges discharges into the sea a weight of earth equal to *fifty-six* great pyramids, and in the other eight months only the weight of *four* pyramids. Now if Professor Sedgwick will only grant us these four pyramids for the snows of the Himalaya, we shall have an annual

superficial wash of soil amounting in weight to sixty pyramids. This is the ordinary and annual work resulting from the operation of ordinary and annual rains on one valley. But how many extraordinary floods, the result of extraordinary rains, have passed *over* the Ganges?

Does Professor Sedgwick think that all this soil comes every year from the erosion of the banks of the Ganges, or even from the valley of the Ganges? If it did, the valley of the Ganges would soon be barer of soil than its declivities. The soil comes from a great part of all the *tops*, and from all the *sides* of all the *declivities* of all the myriads of valleys ramifying from all the tributary valleys of the valley of the Ganges; and what has passed into the sea in the formation of the valley is a mere nothing to what has passed down the valley and does now pass down it, from the denudation of those infinitely extended surfaces *by rain*. In the rainy season, there is, perhaps, a body of *surface*-water which flows down the vale to the sea in volume fifteen times as great as the spring water; and were every spring of the Ganges permanently dried up, the vale would still be flooded every year by a stream in volume only less by a fifteenth part than that which flows every rainy season now, and fourteen times greater than that which flows in the three dry months.*

* Note to third edition. So published in 1866. In 1873 Colonel Holland described the bridge over the Kistnah as 'a viaduct three

The following will show what has formerly come down, and what still does come down the sides of the Himalaya *into* the valley of the Ganges. 'A very ancient subterranean town, apparently of Hindoo origin, was discovered in India in 1833, in digging the Doab canal. Its site is north of Saharunpore, near the town of Behat, and seventeen feet below the present surface of the country. More than 170 coins of silver and copper have already been found, and many articles in metal and earthenware. The overlying deposit consisted of about five feet of river sand, with a substratum, about twelve feet thick, of red alluvial clay. In the neighbourhood are several rivers and torrents, which descend from the mountains charged with vast quantities of mud, sand, and shingle, and within the memory of persons *now* living the modern Behat has been threatened by an inundation, which, after retreating, left the neighbouring country strewed over with a superficial covering of sand several feet thick. In sinking wells in the environs masses of shingle and boulders have been reached, *resembling those now in the river channels* of the same district, *under* a deposit of *thirty feet* of

quarters of a mile long, over a river which at times ran down like a mountain torrent, with from 20 to 30 feet depth of water, sweeping everything before it, and which at other times *was perfectly dry*.' Speaking liberally, we may say that the history of our Indian railroads has been the record of the washing away of such bridges by *rain* floods rooting up their gigantic piers, and wafting away their iron girders, each of hundreds of tons in weight.

reddish loam. Captain Cautley, therefore, who directed the excavations, supposes that the matter discharged by torrents *has gradually raised the whole country, skirting the base of the lower hills*, and that the ancient town having been originally built in a hollow, was submerged by floods, and covered over with sediment, seventeen feet in thickness' ('Principles').

Denudation by rain extends over the whole *space* of the earth. Its *pace* will be modified, hastened, or retarded, or partially stopped, by a thousand such circumstances as comparative hardness of surface, porousness, levelness, vegetation, heaviness of rain, hedges and fences, &c., &c. Over vast tracks, denudation by rain is so slow as to be inappreciable. Still there is, perhaps, scarcely any place in nature where excessive continued rain will not *run;* and this run will be discoloured. This discolouration will be from soil; and this soil will be deposited where the rain ceases to run.

Even where the overflow of a river *stands* and deposits, that deposit may be subject to denudation from local rain after the river, or rather the flood, has subsided; though the deposit of the river may be annually in excess, and accumulation of soil may result, as in all alluvial valleys.

Rain has laid the whole surface of the

But the chief thing which diminishes and retards the effect of the wash of rain is the very force

earth in ridge and furrow.

of the cause. This force, speaking liberally, has thrown the whole surface of the earth into ridge and furrow, into these graduated vales sloping to the sea; so that all the broad superficial runs of this wash are *shortened*, and are made *lateral* into these *longitudinal* channels. We shape our roads high in the middle on this principle, to throw the rain off on each side with the shortest possible run into the ditch or gutter, and to prevent a wash *along* the road, which would otherwise soon wash our artificial road away. Were it otherwise in nature, were there one plane descent from the tops of all the hills and mountains, the volume of the superficial wash of rain, increasing as it descended, would many times in the year desolate the whole of the lower parts of the hills and mountains; and the lower parts of the hill sides would have less soil than the upper parts; they would be as bare of soil as the channels of torrents. The channels of torrents and rivers prevent this effect now; they are nature's ditches and gutters, so that, in this light rivers may be regarded as a conservative, not a destructive, power. But rivers are mere labourers or accessories in the affair. The wash of rain is the engineer which has laid out the gradients of this preventive surface drainage over the entire area of the earth.

The source of the valley is always

The source of the valley is always much higher up than the *source of the river;* I mean than the

spring source of the river, for the snow source or glacier source, being both superficial sources, I consider the same as the rain source of the valley. The river has no power of making a valley above it; but a torrent of rain water has the power of scooping a valley below it. Even on Salisbury *Plain*, which is comparatively flat, and covered with the closest greensward, these dry valleys, or rather continuations of valleys, above the heads of rivers, exist: and that the cause which caused them still works may be argued from the valleys being richer in soil than the tops or sides of the hills, owing to the gentle gradients of the bottoms of the valleys; for other things the same, that is, in the same strata, with the same vegetation, &c., one universal result of the wash of rain is, that the degree of denudation of soil will be directly as steepness.

higher up than the source of the river.

Some of these dry valleys have an almost imperceptible slope, and they might be perfectly level, and yet regular channels for the wash of periodical heavy rain. For if water *can* get out at one end of a level channel, and *can not* get out at the other end or at the sides, it not only *will*, but *must* get out where it *can*,

> —— unda impellitur unda,
> Urgeturque prior venienti urgetque priorem,

and it will carry with it much of the finer soil formed by disintegration and vegetation.

When these chalky downs are ploughed up, the brow of the hill shows light, and the soil darkens in descending. This is from the rain washing the soil quickly down the hill, which is not so quickly supplied to the brow from the flatter top of the hill. Here the universal wash of rain may be *seen*.

When one field comprehends the head of an entire coomb in a chalk country, the semicircular brow of the coomb in like manner shows light, and the soil darkens to the bottom of the coomb. When such a field is cropped, the crop also is light on the brow, and heavy in the bottom of the coomb. Here the universal wash of rain may not only be *seen* by the farmer, but *felt* by him.

Terraces formed by hedges.

This universal portage of soil by rain, the *eternal* effect of *eternal* causes, which in huge spaces of *time* results in such vast geological changes, may also be *seen* oculis fidelibus whenever a fence runs horizontally along the side of a hill. A *natural terrace* is then formed. For aqueous denudation goes on below the fence, and in chalk countries the ground becomes white; and not only does aqueous denudation cease above the fence, but aqueous deposit takes place, and the good soil which was on its way to the valley is arrested. Even a slight dead wattle, if kept up, will produce this effect, and though the hedge is dead the ground on which it is placed will

grow. In France I have seen deep terraces result from very narrow strips left uncultivated to divide fields or properties. If the subsoil is hard rock, say the Devonian limestone or slate, the rock shows bare below each horizontal fence, and rich soil collects above it.

A gateway wrongly placed will often let considerable quantities of this collection of the best soil escape, which might otherwise have accumulated for what man might call for ever. So an injudicious down-hill waggon-way, across fields, will sometimes act as a channel, and catching soil laterally convey it away from its proper owner. If your neighbour's land lies below you on a steep hill side, unless you wish to make him a present of your best soil, pound it back on to your own land by a fence, and when it accumulates against your fence cart it up the hill again.

The beautiful *artificial terracing* of the hill side, which we see in southern mountain cultivation, originates in the necessity of catching the stream of soil from above, and preventing its farther descent to the valley below, down which it would be washed, whether it were a dry valley or a river valley.

In unusually heavy rains, numbers of these terrace walls give way; and when a terrace goes which is high up the hill side, a sort of earthen avalanche takes place, bearing crops, soil, and stone walls in succession to the vale below.

In these works man shows himself as a strong *conservative*. In alluding to man as a *leveller*, our great geologist admirably remarks: 'By ploughing up thousands of square miles, and exposing a surface for part of the year to the action of the elements, we *assist the abrading force of rain*, and diminish the conservative effects of vegetation:' and by *fencing* these thousands of square miles, man acts as a very universal conservative. The existence of upper valleys or dry rivers of soil, proves that, were there no such things as rivers on the globe, the scooping power of agglomerated rain would still give the same alternation of hills with valleys sloping to the sea which now obtains, and the same waste and denudation from lateral wash would still take place. The river only makes its own channel (which is much enlarged by rain floods), and in that channel assists in conveying away the denudation brought to it by rain, which would otherwise travel more slowly *along* the valley, and *out* of the valley, by the same force which brought it *into* the valley—Rain. I believe that in many cases where the country is composed of soft and porous materials, as chalk, the depth of the valleys and channels scooped out by rain lays open the springs, and forms the rivers, instead of the rivers forming the valleys. How many dry valleys are there sloping to the sea, without having laid open a spring, and therefore without

any stream? And what formed these valleys? How many lateral or branch dry valleys are there falling into the main longitudinal dry valley, whose lower end joins the upper end of the river valley? And how many lateral or branch dry valleys fall into the main river valley? And what formed these countless myriads of dry valleys?—Rain.

Nothing can be more pellucid than our Hampshire streams, except in heavy rain. And to look at them we should not say that they carried much soil to the sea. But throw a dam across the valley and form a pond. Deep mud is instantly deposited over the whole bottom of the pond, and a boggy delta where the stream enters. This is from the lateral wash of soil into the river in heavy rains. We have only to look at the complexion of the river to see this. And the river deposits the mud in the pond, which it would otherwise have carried down to the sea. I will instance the ponds at Alresford and at Warnford. This was so published in the first edition in 1857. At this moment (November, 1858) an enormous gang of *navvies*, at an enormous expense, are emptying of mud the artificial lake at Avington. Yet the lake is clear of the main stream of the Itchen, which still deposits the main *stream of mud below*, that is, in the sea and on the banks of the Southampton water, while *above* Avington every branch of the Itchen has its mud-trap, namely,

Alresford pond, the artificial lake at the Grange, and that at Tichborne. Every river, even the purest and clearest, is an *outlet* of mud as well as of water. And every puddle, and every pond, and every lake, and every sea, is a *receptacle* of mud as well as of water.

Rivers outlets of mud as well as water.

The same causes which deposit mud in each puddle in the road have formed, and are still forming, the deposits of gold from quartz, and of china clay from granite. Nature is not only the great quartz-crusher by decomposition, but also the great gold-washer by rain and rivers. And whenever circumstances will permit she sifts and sorts the drift, and drops the gold down on to the 'bed-rock' on which the alluvium rests, or to the bottom of each stratum of the alluvium as perfectly as the gold-washer does to the bottom of the box below his cradle. However geologists may differ as to how *matrix* gold *got into* quartz, or as to how flints *got into* chalk, every geologist in existence will agree as to how each of these *got out* of its matrix, namely, that it has been *rotted* out. There is not a geologist existing who will not allow that *alluvial* gold has once been *matrix* gold, and that it has been *rotted* out of the rocks which contained it by atmospheric disintegration, as surface flints come from the rotting of the chalk which contained them into soil, and as china clay comes from the rotting of granite. Now granite and quartz are two of the most durable rocks on earth, yet the very geologists

Gold alluviums.

who allow this enormous rotting of these, the hardest rocks, deny the constant decay of the softer ones. Gold released from rock by rotting, like flints released from chalk by rotting, may lie on the surface for ages before it is drifted into an alluvial bed by water. But of all the drift driven by water gold is the heaviest, and so has a tendency to sink sooner and deeper than anything *of the same size and shape.* Alluvial gold, therefore, is found on the rock or bed on which the alluvium rests, because that is the bottom of the first stratum. So it is found on the top of the first stratum, because that supports the bottom of the second stratum, and so the divisions or partings of the strata are the chief receptacles for the *coarse* gold, as it is called, though fine particles may be washed out of any part through an alluvium of perhaps 300 feet in depth, and any number of miles in length.

The builders of these enormous deposits have not been monstrous convulsions or disastrous floods, still less 'glacial epochs,' but simply rain and rivers, that is, quiet atmospheric disintegration and the wash of rain. That these builders were at this work before our era we have the word of 'The Father of History,' who describes the gold dust of the Pactolus as coming from the degradation of mount Tmolus, τὸν Πακτωλὸν ποταμὸν ὃς σφι ψῆγμα χρυσοῦ καταφορέων ἐκ τοῦ Τμώλου. And that these builders are still at this work I quote a practical witness.

Mr. Howitt writes ('Land, Labour and Gold,' letter xxxv.), 'These slates, sandstones, and other perishable substances holding gold being thus brought to the surface (where they are in places so conspicuous near these perpendicular dykes lately described), have gradually undergone decomposition from the action of the atmosphere and of rains, and this by degrees liberated the gold which has been washed into the streams and valleys. *This action is still going on, and, therefore, after great rains, you will often find gold deposited in the roots of the weeds and shrubs in the creeks.*' 'A most striking proof of the results of *the gradual decomposition of the surface*, we found in the creek which we worked at the Upper Yackandanda. The gold was found in the mud of the creek, resting on a stratum of clay, at about a depth of two feet. But on digging through the clay we found fresh drift of three feet deep, which must have been the accumulation of centuries. Neither in that, however, nor in the rock beneath, was there the slightest deposit of gold. It was quite evident that the gold had only begun to wash into the creek from the surrounding slopes at a comparatively recent period, because these slopes had only then begun to undergo decomposition.'

China-clay.

A sudden flood cannot *rot* or decompose. But how many centuries must it have required to *rot* and decompose the granite from the felspar

of which the china-clay beds of Cornwall and Devonshire come? The same rotting is going on now. The Tor reverses the law of the sugar-basin. The blocks of granite get small directly as they near the top, because they are melting motionless in the atmosphere like lumps of sugar in moisture. The surface granite on the summit of the Tor is as different from what is quarried from below as the surface of the flint is from the interior. But, as Sir Henry De la Beche remarks (Cornwall and Devon, page 449), Tors only exist because they are *harder* than the beds which *have* surrounded them, and (as I have said of the Weald Hill and the North and South Downs) those all-powerful excavators air and moisture, rain and rivers, have as much *formed* these Tors out of the Dartmoor dome of granite as the sculptor has formed the statue out of the Parian or Carrara block. And the human and the natural operators have worked on the same principle, that is, by the abstraction of external parts. And the Tors of Dartmoor stand out a magnificent *monument* of the enormous masses of granite which have vanished by disintegration of the atmosphere and the erosion of rain and rivers. These Tors, however, though the *monument* are by no means the *measure* of this denudation, since they have themselves been melting away for an "eternity of time," and are day by day vanishing tenues in auras at this instant.

Everything on the surface of the earth which is not living is decaying. And as decay produces soil, all vegetation, and consequently all life, depends on the decay of what has not life. This is as old as Confucius; his last words were, 'The great mountain must crumble, the strong beam must break, and the wise man wither away like a plant.'

CHAPTER XI.

ABSURDITY OF THE 'IGNEOUS FUSION' THEORY.

IT IS ONLY *FIRE* WHICH KEEPS OUR HEADS ABOVE *WATER*. CIRCLE OF CAUSES. PHYSICAL GEOGRAPHY OF SOLOMON, HOMER, AND HERODOTUS. SOLIDS SUSPENDED IN LIQUIDS OBEY THE LAWS OF LIQUIDS. ORANGE SHAPE OF THE GLOBE OWING TO THE ACTION OF CENTRIFUGAL FORCE ON LIQUIDS. ABSURDITY OF THE DOCTRINE OF THE ORIGINAL INCANDESCENT FLUIDITY OF THE GLOBE. COMPARATIVE EVAPORATION FROM SURFACES OF EARTH AND WATER.

It is only *fire* which keeps our heads above *water*.

IT is only fire which keeps our heads above water. It is only owing to subterranean igneous action that the solids of the globe are not submerged below, shall I say, 3000 feet of water. It is true that the quantity of liquid in comparison to the solids of the globe is infinitely small. But, owing to one of its attributes, water plays a part infinitely great. That attribute is, that like the atmosphere, it *will* get to the top. So that, notwithstanding our friend fire, water even now covers three-quarters of the surface of our globe. But water not only has a tendency to find one level for itself, but to reduce the solids of the globe to one level. And as this principle is for ever at work, a uniform level of all solids would take place below water but for fire.

The great Laplace has *guessed*, as some think very erroneously, that the *average* depth of the sea might be about the *average* height of the land, or 3280 feet. From Sir James Ross's soundings ('Principles,' page 105), it would appear that *the greatest depths* of the sea may not differ much from the *greatest height* of mountains.

Our highest mountain would be represented by a grain of sand, on a globe of six feet in diameter. Therefore, the deepest part of the sea would be represented by the *cast* or impression of a grain of sand on such a globe. What a puddle, then, is the sea, in point of cubical contents, compared with the solid globe! But withdraw the inequalities of the solids and the puddle flows over them, and

Full fathom five thy father lies,

together with all organic terrestrial existence.

Circle of causes.

This appears paradoxical, because in our everyday experience we see liquids running down solids, and seeking a level below them. The reason is still more paradoxical, as follows: Though water is *heavier* than the air, it is perpetually *ascending* through the air in the form of vapour. It is then condensed, and *descends* as rain, or snow, or dew. What is not evaporated, *runs down* to the sea, either continuously on the surface, or, if it sinks below the surface, by springs and rivers, and the largest rivers are merely returning vapour. This water carries with it solids to the sea, which sink to the bottom

of the sea; and the same act which sinks the solids of the globe raises the liquids of the globe. Every one must see that this all-pervading* ever-acting circle of causes must result in depositing existing continents under the sea. And this is going on now, and has been going on, as man might say, from all eternity; and as old continents have disappeared, new continents have been raised, and old ones hoisted farther up by subterranean igneous action. And I end this paragraph, as I began—it is only fire which keeps our heads above water.

Physical geography of Solomon, Homer, and Herodotus

Evaporation, then, from the surface of the globe must precisely equal the rainfall on the globe, and speaking *liberally* the waters returned by rivers to the sea must equal evaporation from the sea. That is, rivers, which are returning rain, are simply the equivalent of evaporation from the sea. Solomon and Homer (the most ancient geologists and physical geographers that I know of, not excepting Humboldt's Eratosthenes) both make rivers to flow *out* of the sea as well as *into* it. Solomon, Ecclesiastes, chap. 1, says, 'All the rivers run into the sea, yet the sea is not full. Unto the place *from whence* the rivers come thither they return again.' Homer's words are:

> Οὐδὲ βαθυῤῥείταο μέγα σθένος Ὠκεανοῖο
> Ἐξ οὔπερ πάντες ποταμοὶ καὶ πᾶσα θάλασσα
> Καὶ πᾶσαι κρῆναι καὶ φρείατα μακρὰ νάουσιν.
>
> *Iliad*, 21, 195.

* As I have stated in the Geological Magazine for August, 1864, 'I consider a rainless district to be an impossibility.'

I do think that *evaporation* from the sea is here alluded to, but that rivers are supposed to *flow* (*νάουσιν*) *out* of it. Certainly Herodotus took this view of the Homeric doctrine. In 'Enterpe,' 21 (Beloe), he ridicules the idea 'that the Nile has these qualities as *flowing* (*ῥέοντα*) from the ocean.' And again, 23, 'The argument which attributes to the ocean these phenomena of the Nile, seems rather to partake of fable than of truth or sense. For my own part I know no river (*ποταμὸν*) of the name of Oceanus; and I am inclined to believe that Homer, or some other poet of former times, first invented and afterwards introduced it in his compositions.'

Solids suspended in liquids obey the law of liquids.

The circle of causes alluded to also determines the form of the globe. For while solids are suspended in liquids they obey the same laws as liquids; and as the globe has, for countless ages, daily spun on its axis, its surface solids being as obedient to centrifugal force as liquids, it has been whirled into the form of an orange or flattened ball; though fire continues occasionally to lift an old continent, or to poke up a new bit above the natural aqueous surface of the ball.

Orange shape of the globe owing to action of centrifugal force on liquids.

Playfair originated this idea in his magnificent illustrations of our yet unappreciated Hutton. Herschel, the immortal son of an immortal father, has confirmed it. Herschel, however, with Lyell, makes the sea, acting on its shores, 'grind down' the solids, instead of the universal circle of causes.

If this is so, we shall have some high cliffs at Chimboraço, and along the Andes. A cliff 24,000 feet in height would be worth seeing. What a squat, tame cone the Peak of Tenerife would be to this! But what average height would *Orographers* allow for the cliff from Panama to Patagonia? 15,000 feet? Inconvenient for landing even if it was only 1500.

Natural causes, however, now in action, are sufficient to have given this world the form of a flattened ball. And we may reject the idea of the original fluidity of the globe, whether igneous or aqueous, and the universal chaotic ocean, velut ægri somnia.

Absurdity of the doctrine of the original incandescent fluidity of the globe.

I will take Mr. M'Clausland ('Sermons in Stones'), as the latest expositor of the 'igneous fusion' theory, which was originated by Leibnitz nearly two centuries ago (1680). According to this theory, the globe began as a mass of matter melted by heat. As it cooled, a coating of granite formed; then vapours condense, and form a sea over the entire globe. No dry land exists till the Devonian period. Between the granite and the Devonian beds are deposited, over the whole globe, 1st. the Azoic or Cambrian beds, 26,000 feet thick, and above these, the Silurian, 30,000 feet thick, making together a coating to the entire terrestrial globe of upwards of ten miles in thickness. This enormous growth over the entire globe is, 'grain by grain, and

layer by layer, *raised* by *deposit from* the granite bed of the ancient ocean.' That is, it is raised *from* the bed *on* which it is deposited, so that the last or uppermost mile of deposit must have passed through the first or lowermost nine miles of deposit.

It is true that in other parts of the work mud issues from the melted mass, and '*muddy vapour*' from the sea. But how mud got into the mass melted by heat, or how it issued from the melted mass as mud, does not appear. But suppose sufficient *incandescent* mud to be ejected to increase the diameter of the globe at any and every point twenty miles, would there be no collapse? or no inletting of the sea? and consequent laying bare of dry land?

Laplace put the average depth of the sea at 3000 feet. I wish he was at my elbow to tell me how much it would be shallowed by Mr. M'Clausland's raised bed of 56,000 feet as long as this bed was water-tight. And when it began to leak, and to let 3000 feet of water into the chambers which formerly held 56,000 feet of incandescent mud, or half, or a quarter, or a tenth part of it, whether the entire surface of the globe would not be *dry land?* with that surface as smoothly horizontal as the ocean at its calmest. This would indeed well account for the appearance of *some* dry land in the Devonian period, when according to Mr. M'Clausland, dry land first appeared; though, according to common sense, *till* dry land *did* appear there could

be no denudation, and consequently no deposit on 'the granite bed of the ancient ocean.'

If the incandescent theory is true, I think it follows that in process of time, as internal heat cools, all organic existence, vegetable and animal, *must die a natural death of cold.* Also that as internal heat ceases to replace continents as they are washed beneath the wave, we must end in a chaotic ocean, as the incandescent theory supposes that we began. In such a case, however, Mr. M'Clausland, though deprived of his incandescent mud, could still 'coldly furnish forth,' over the entire submarine earth, a coating of ten miles thick. But he would never get his steam up for another Devonian period, or for any farther change.

But is not all this to take the affair out of the hands of the Creator? to bring His magnificent machinery to a stand-still of itself, like a mundane clock, unless it be constantly wound up? Or rather is it not pure Brahminism? For 'Brahma on awaking from sleep always finds the world a shapeless ocean.' And when Brahma goes to sleep again 'the universe is reduced to one vast ocean.'

Comparative evaporation from surfaces of earth and water.

Very great philosophers have asserted that evaporation from surfaces of *moist* earth is as great as from equal surfaces of water. If this is true, it does not follow that we are equally indebted to equal surfaces of land as to equal surfaces of water for our rain, since surfaces of earth have a trick of becoming *dry*

after a certain degree of evaporation. That we are mainly indebted for our rain to evaporation from the sea I stated thus in a letter to the Hampshire paper in September, 1845. The moisture which rises through the air must be equal to that which falls through it. But vast quantities (say half) which fall on earth run into the sea by rivers. If then no more moisture rises from water than from an equal surface of earth, during the year, we come to the absurd conclusion that the sea must increase every year by half the quantity of rain which falls on the land, that is, by *all* the water which flows to the sea by rivers, besides the excess of dew which falls on water, which, according to Hales, is more than double that which falls on equal surfaces of land.

As the moisture which is absorbed by vegetation is returned to the atmosphere, I consider it in the same account as that which is absorbed and returned by the earth. For vegetables while they live exhale, and when they die they dry. If a tree lives a thousand years, and its heart wood is always moist, even if it were proved that that moisture were unchanged, the thousand years come to an end, and on the average, a year's absorption of moisture by vegetation is annually returned to the air.

No standing water, however, can retain the same level for two successive days, but must be always rising from rain or falling from evaporation, and, as I suppose, the vast evaporation from the tropical sun

must be the cause of the vast abundance of the tropical rains. When we consider the difference of level from these opposite causes every instant progressing in open oceans, the marvel is that the currents are as gentle and as *regular* as they are *supposed* to be. I say *supposed*, because if the accredited theory is true, I think there *should be* a hole in the surface of the sea between Cape Horn and South Victoria, and a hill of water at the east end of the Gulf Stream; at least, a perpetual enormous influx is supposed into the North Atlantic without any outflow. Herschel, 'Physical Geography,' page 13, second edition, says, 'The excavation of the Gulf of Mexico and the Caribbean sea is an evident effect of the continued and powerful action of the Gulf Stream, or rather of the general set of the great South Atlantic current on that part of the American coast which issues thence at present in the concentrated form of the Gulf Stream, and which unless counteracted by other causes must sooner or later cut through the Isthmus of Darien.' This is putting the cart before the horse with a vengeance. Sea currents must conform to the land. But that land should conform to sea current is about as likely as that the cart should draw the horse instead of the horse the cart. Besides, neither the Gulf Stream which comes out of the gulf through Florida Channel, nor the stream which goes into the gulf through Yucatan Channel, neither of these

streams goes near the Isthmus of Darien. The stream which enters the gulf passes across the north-eastern part of the Caribbean sea. Darien forms the south-western shore. If there is any virtue in Herschel's notion the provinces of Yucatan and Florida should have vanished long ago, and the Cape of Good Hope and South Africa should have been carried off by the Cape current and the 'great Southern Atlantic current.' But there all the three stand as large as life. And why does Cape St. Roque stand out a pyramid and brave the main equatorial current with its point? According to Herschel, instead of a cape there should be a 'Gulf of Brazil' here.

CHAPTER XII.

THE EARTH AND MAN ETERNAL, UNLESS DESTROYED BY THE WILL OF GOD.

GENERATION OF SUBTERRANEAN HEAT. THE EARTH ETERNAL UNLESS DESTROYED BY THE WILL OF GOD. THE EXISTENCE OF SPECIES TRANSITORY, AND DEPENDENT ON SECOND CAUSES. PERPETUAL CHANGE OF CLIMATE, AND PHYSICAL CONDITIONS OVER THE WHOLE GLOBE. INSULAR CLIMATE RESULTS FROM CURRENTS OF AIR, NOT FROM CURRENTS OF THE SEA. THE EXISTENCE OF SPECIES OF ANIMALS DEPENDENT ON THE PHYSICAL CONDITIONS OF THEIR *STATIONS*. BUT SPECIES ARE NOT THE *RESULT* OF PHYSICAL CONDITIONS. BUT ARE *SUCCESSIVELY* CREATED. DISTINCT STATIONS HAVE DISTINCT CREATIONS. SPECIES ARE REPLACED BY OTHER SPECIES AS THEY DIE OUT. THE EXISTENCE OF THE SPECIES MAN DEPENDENT ON THE WILL OF GOD ALONE.

Generation of subterranean heat.

SIR HUMPHRY DAVY, having made the magnificent discovery that the bases of several of the earths and alkalies are metallic, accounts for the generation of subterranean heat and action in an equally magnificent way, by the infiltration of water through the earth's surface and its contact with these unoxidised metallic bases. In this case, these bases would absorb the oxygen of the water and would liberate the hydrogen, generating a heat sufficient to *dissolve* all surrounding rocks, irrespective of their *disruption* from the escape of the

elastic vapour produced. Lyell supposes 'that the hydrogen evolved during the process of saturation may, on coming afterwards in contact with the heated metallic oxides, reduce them again to metals; and this circle of action may be one of the principal means by which internal heat and the stability of volcanic energy are preserved.'

The earth eternal, unless destroyed by the will of God.

If these doctrines are correct, the circle of causes, now in operation, is perfect; and there is no reason why the existence of this world should ever *go out of itself*, or perish except by the will of the omnipotent God who created it.

The existence of species transitory, and dependent on second causes.

This is not so with the species of plants and animals which exist on the globe. Unless we except man (as I think we may), the existence of all organic species is not only finite, but it is transitory as compared with the existence of the globe, and it depends on second causes.

Perpetual change of climate and physical conditions over the whole globe.

Every local change in physical geography works not only a local but a general change in climate and physical conditions over the whole globe. The admirable Lyell accounts most magnificently for the vast changes of the general temperature which have evidently taken place over the whole globe, and shows that these changes are, and ever will be, taking place. That is, directly as land increases in polar regions and decreases in equatorial regions, cold increases over the whole surface of the globe; and directly as land increases

in equatorial regions and decreases in polar regions, heat increases over the whole surface of the globe. Locally, the climate of the west coasts of the northern hemisphere is more temperate than the climate of the east coasts. I think that this is owing to the currents of the air and not to the currents of the sea. That is, it is owing to the prevalence of west and south-west winds, and not to 'the Gulf Stream.' These winds, tempered by the sea, modify the continental cold in winter and the continental heat in summer. British Columbia and Vancouver's Island may be said to be in the same latitude as Labrador and Newfoundland. But in British Columbia domestic cattle live out of doors through the winter. What is the reason of this? Is there a Gulf Stream in the Pacific?

Insular climate results from currents of air not from currents of the sea.

Owing to these changes, local and general, there has been a perpetual change of species existent on the globe. I will mention in exemplification that land animals of the *kangaroo* kind have been found in the *English* oolitic Stonesfield slate, and later, in the tertiary fresh-water beds of the Isle of Wight, land animals of various sorts, but *all* of extinct species. The vast variety of *extant* and *extinct* land animals contained in the English drift beds will be alluded to in chapter xiv.

The existence of species of animals dependent on the physical conditions of their *stations*.

Nature has *not* indeed grouped her flora or her fauna *solely* in reference to soil and climate, that

is, in reference to the agreement or disagreement of the physiological constitutions peculiar to the plants or animals with the physical conditions existent in each district of the globe. Were it so, that is, were the same species of plants and animals *always* found under the same physical conditions, it might, with more reason, be argued (as has been argued by Lamarck) that *vitality itself* is the mere result of physical conditions; that the different *constitutions* of plants and animals are the result of different physical conditions; that the different *species* are mere changes of form and organization resulting from different physical conditions, and that *man himself* is merely the final result of these manifold changes from the zoophyte upward.

But species are not the *result* of physical conditions.

The Great Artificer authoritatively and absolutely contradicts all this, by having, possibly from all time, and apparently *successively* and at distinct times, and in comparatively modern times, created distinct existences or species, and kept these distinct species separate under precisely similar physical conditions. This is the case with animals, vegetables, birds, reptiles, insects, fish, shell animals, and zoophytes, whether any of all these named are terrestrial, or aquatic, or amphibious, or peculiar to fresh, brackish, or salt-water. And not only is this so now, but apparently through an indefinite number of ages the terra-

But are successively created.

queous globe has thus been gradually and *in succession* stocked and restocked with species entirely distinct from those existing in this or in any two of the different periods. Indeed, supposing species to have originated from single stocks, the creation of existing species could not have been simultaneous. Had it been simultaneous, all animals, herbivorous or carnivorous, must have fasted or have destroyed whole species at a mouthful. Creation must have been successive as far as this, plants must have multiplied before herbivorous animals were turned among them, and herbivorous animals must have multiplied before carnivorous animals were allowed to prey on them.

Humboldt says no. Humboldt says we might have lived on fish, which were doubtless created in shoals. For 'the existence of races of men inhabiting the icy regions of the north polar lands, and whose nutriment is solely derived from fish and the cetaceans, shows the possibility of maintaining life independently of vegetable substances.' And animals? and birds? Horace's doves and hinds? were they, too, ichthyophagous? Did Horace describe the actual ancient state of things when he hung his elm-boughs with fish, and floated his hinds on the briny wave?

> Piscium et summa genus hæsit ulmo,
> Nota quæ sedes fuerat columbis,
> Et superjecto pavidæ natarunt
> Æquore damæ.

The Pythagorean account of creation, as given by Ovid, agrees with the Mosaic in mentioning the creation of fish first, but it is guiltless of the glaring absurdity of leaving the land and the air lifeless and tenantless for millions of years. On the contrary, Ovid says:

> Neu regio foret ulla suis animalibus orba
> Terra feras cepit, volucres agitabilis aer.

This absurdity was reserved for Humboldt and the moderns.

From the polar to the tropical regions a wonderful variety of physical conditions exists, and an equally marvellous variety of species and of physiological constitution in all the classes named displays itself. The whole of the land and of the water, and even of the air of these and of all intermediate regions are crammed full of organic existencies. We all see this in temperate regions; and I will instance only some of the largest quadrupeds, herbivorous and carnivorous, on the extremes of cold and heat, because these could not exist in regions which were not replete with vegetable and animal life for their food. In the arctic regions we find the musk-ox, the reindeer, the huge polar bear, the wolf, the seal, the narwhal, the whale, &c.; in the tropics, the elephant, the rhinoceros, the camel, the giraffe, the lion, the hippopotamus, the shark, &c. But nature is by no means content with this wonderful adaptation

of her organic creation to differing physical conditions. Like the chicken-fancier, who keeps his fowl-yards separate, nature seems purposely to have contrived *different* stations with *similar* physical conditions, in order to exhibit the profuseness of her creative power, in cramming all full of animal and vegetable existences, with constitutions similar to those of similar but separate stations, but the species of each similar separate station differing entirely from the species of all other similar separate stations. These stations are in general kept separate by what Buffon called 'natural barriers.' Besides the difference of climate, resulting from difference of latitude, difference of altitude and seas of water, or of sand, or of eternal snow, in general separate terrestrial districts; continents, currents, difference of depth, saltness, freshness, or temperature of the water, separate aquatic districts. M. Alph. de Candolle, son of the great De Candolle, enumerates twenty-seven great *nations* of distinct indigenous aboriginal plants. That the plants and animals of such vast districts of stations as America and Australia should be different from those of every other part of the globe, from which they are so completely divided, does not strike one with so much astonishment as that there should be 'found one assemblage of species in China, another in the countries bordering the Black Sea, and a third in those

surrounding the Mediterranean.' Here, distance and prior occupancy seem to take the duties of natural barriers. But, however small, and however comparatively modern, the spot, if it be inclosed by natural barriers (as, for instance, St. Helena), it will apparently have a creation for itself.

Distinct stations have distinct creations.

So in the Galapagos islands, of which there are ten principal islands, under the line, 600 miles westward of America, of modern origin, judging from the fresh appearance of about 2000 craters. Lyell says of them: 'Although each small island is not more than fifty or sixty miles apart, and most of them are in sight of each other, formed of precisely the same rock, rising nearly to an equal height, and placed under a similar climate, they are tenanted *each* by a different set of beings. Of twenty-six different species of land-birds found in the Galapagos archipelago, all, with the exception of one, are distinct from those inhabiting other parts of the globe; and in other archipelagoes, a single island sometimes contains a species found in no other spot on the whole earth.' Wings themselves furnish no exception to the rule. The Creator hangs his cages, containing distinct birds, in distinct separate regions, though those distinct regions may have precisely the same physical conditions. Lyell quotes Darwin: 'The archipelago is a little world within itself. One is astonished

at the amount of creative force displayed on so many small, barren, and rocky islands, and still more so at its diverse, yet analogous, action on points so near each other. I have said that the Galapagos archipelago might be called a satellite attached to America; but it should rather be called a group of satellites, physically similar, organically distinct, yet intimately related to each other, and all related in a marked, though much lesser, degree to the great American continent.'

But the plan of the Great Creator seems in all time, and in all terrestrial space, to have gone on 'qualis ab incepto;' and as he has subjected individuals to death by years, so he has made species mortal by geological change of physical conditions. Nay, he has made their actual local habitations mortal. It is not to man only that he has said 'dust thou art and unto dust shalt thou return,' but to the hardest rock, and to the highest mountain of the hardest rock. He has throughout all time made *continents* to come and to go—to have a birth, life, death, and burial. He wields the mighty power of subterranean igneous action, in raising them into hypæthral existence; and, as if to show their nothingness in his hands, he redeposits them in the subaqueous regions by the quiet action of the raindrop from heaven, or, at his will, he places his almighty finger on the mountain-top, and submerges it bodily below the

Species are replaced by other species as they die out.

wave. And he has always, as species died out, and doubtless continues, even at this moment, to originate single stocks of new plants and animals, which radiate from where their Creator first locates them, as far round as his natural barriers will allow them.

The existence of the species man dependent on the will of God alone.

Man, by his mental qualities, that is, by his arts, not by his physical constitution, o'erleaps all 'natural barriers.' His 'station' is the globe, and there must be wonderful changes in the 'physical conditions' of its entire surface ere man could be exterminated *by them.* Man might survive any number of continents; and his existence is apparently confided to no second causes, but hangs like that of the globe itself on the fiat of his Almighty Creator alone. Thus much I think that we may say from what we see at this moment going on around us. Thus much I think that we may *guess* as to what has *immediately* (I refer to geological time) preceded, and as to what may immediately follow our time. He who goes farther than this, he who, like Darwin or Stenny Hunt, attempts to account for a *beginning* of any existence whatever, animate or inanimate, attempts (as I think what he will not accomplish) to lift the veil of Isis. The intercourse and intertraffic of man's station, the globe, was doubtless never so complete or so rapidly advancing to perfect completion as at this moment. Practically, England has been

the great worker here. Theoretically, I think that Adam Smith has received a millionth part of the honour which is due to him.

CHAPTER XIII.

FIRE FORMS CONTINENTS, WATER TRANSFORMS THEM.

HUMBOLDT FORMS CONTINENTS BY '*FUSION*.' HOLLOWS FORMED IN THE FIRST ELEVATION OF THE LAND ARE NOT VALLEYS. SEAS AND LAKES ARE NOT VALLEYS. HUMBOLDT SAYS THE ATLANTIC *IS* A VALLEY. AND FORMED BY RUNNING WATER. WHAT A VALLEY *IS*. THE *BASINS* OF LONDON, PARIS, AND HAMPSHIRE ARE *NOT VALLEYS*.

As will have been seen in chapter XI., it is not meant to deny the all-dominant influence of fire on the form of the land of the globe. Fire first raises the continent, and, therefore, first forms it. Rain afterwards *transforms* its *surface*. Subterranean igneous heat is the quarryman who raises the block. Rain is the artist who shapes its surface. 'Beauty is but skin deep.' We are not the less for that touched by beauty, nor by the exquisite beauty of the *surface* of the earth. We owe this beauty of the surface to water, not to fire. Could the labourer of Paros with justice write:

Non me Praxiteles fecit

on some divine production of the artist? Did Bailey form his exquisite Eve, or the workman of

the Carrara quarries? This forming or *transforming* of the surface is, however, all that is claimed for rain.

On the subject of the original forming of the land by fire, Humboldt uses plenty of sesquipedalian words, and quotes authors from Eratosthenes downward. I shall be satisfied with one quotation from one author:

Parturiunt montes, nascetur ridiculus mus.

With regard to the *cause* of the form of the land: 'Very little can be empirically determined regarding the casual connection of the phenomena of the formation of continents, or of the analogies and contrasts presented by their configuration. All that we know regarding this subject resolves itself into this one point, that the active cause is subterranean, that continents did not arise at once in the form they now present, but were, as we have already observed, increased by degrees, by means of numerous oscillatory elevations and depressions of the soil, *or*, were formed by the *fusion* of separate smaller continental masses.' Humboldt forms continents by '*fusion*.'

With regard to the *effect* of this cause, in conjunction with Bacon, Polybius, and Eratosthenes, Humboldt calls our attention to 'the pyramidal configuration of all the southern extremities of continents.' Here we become mithraic, and Humboldt shows us more PYRamids even than Eratosthenes.

The letter A has also a 'pyramidal configuration,' and four out of five of our continents, which end in pyramids, begin and end with this pyramidal letter, ASIA, AFRICA, AMERICA, and AUSTRALIA. Axis, Arctic, and Antarctic also begin with it. These coincidences cannot be accidental. I do not pretend to class myself with the gentlemen named above. But I do think that this one *original* idea of mine is likely to be as useful, and is in all respects as worthy consideration in a co(s)mical way, as their joint stock company one.

It is true that 'lands-ends' *are apt to be pyramidal,* to whatever point of the compass they may face. And if we saw as much of the northern lands-ends of our continents as we do of their southern lands-ends, they might show a fair share of pyramids. Indeed, since the time of Eratosthenes, the north of Europe at the north cape, and of Asia at the north-east cape, have been found to be pyramidal—nay, Cape Maimorskoi is obeliscal. Abstract the islands (which are themselves pyramidal to the north) and the whole north coast of America, from Point Barrow to Hecla Strait and Hudson Strait, is pointed throughout with pyramids to the north.

But, 'as the fool thinks, the bell clinks,' and if a man happens to be a fire-worshipper, and *wishes* to see a pyramid, he will see one in the

section of a circle, and out of a square he will make four beauties. If a man does *not* wish to see pyramids, I do not think that he will see them in the south of Australia and New Zealand, which Humboldt quotes as continents, more than he will on the north of them, or of Borneo, or any *island* north or south from Iceland to Madagascar.

Humboldt might make four pyramids out of the Isle of Wight, though it would then be three to one against his southern theory. For, instead of all facing the south, they each face a cardinal point. And 'the active cause' of these 'pyramidal configurations' has been water, not fire. For the eroding force of the sea, being horizontal, forms horizontal pyramids, as the eroding force of rain, being vertical, forms vertical pyramids. Fire has had nothing to do with the form of the island farther than having raised it as a part of the mass which joined both England and France. Water is the sculptor who has formed the island out of this mass, and will continue to transform it till it has swallowed the last grain of it.

The *original form* given to the 'Weald *valley*' by fire, was one smooth *hill*, or hog's-back, running from the north of France westward, and covered with one single stratum, or geological formation. The *present form* of the region is due to water. To water we owe its infinitely varied features and

beauties, its infinite alternation of ridge and furrow, hill and dale, its infinite ramification of stream and valley, streamlet and *valleylet*, and its great variety of geological strata. Nay, like the Isle of Wight, its very hills are as much *formed* by water out of the original mass as the statue is formed by the sculptor out of the original block.

Hollows formed in the first elevation of land are not valleys.

But since all the protuberances of the earth's crust have been thrust up by subterranean fire, and as the intervals between these protuberances may be called hollows, it may perhaps be asserted that these hollows are valleys, formed by fire, not by water.

Seas and lakes are not valleys.

All seas and lakes are such hollows. From the top of Mont Blanc in the Alps to the Rocky Mountains in North America, or to the top of Chimboraço in the Andes, may in this sense be said to be a hollow. From the Andes westward to the Himalaya another, and between Europe and Africa a third. If these hollows are called the *valleys* of the Atlantic, Pacific, and Mediterranean, then I confess that there are valleys in the world not formed by water.

Humboldt says the Atlantic *is* a valley.

I might, however, still fight, and that with Humboldt on my side. The last recruit I should have expected certainly; ἄριστον μὲν πῦρ should be his order of the day. For, be it a continent, a hill, a dale, or a river, fire is his word. His continents have a 'PYRamidal configuration' from

fire. He stratifies his coal-beds by fire.* On fire-inflated *bladders* his single mountains rest. On fire-formed fissures he supports his mountain ranges. In his river courses he leads the flow of water by fire, and he *fissures* forth his *terrestrial* valleys by fire, still fire. But in his *oceanic* valleys, he turns short round to the Pindaric ἄριστον μὲν ὕδωρ.

And formed by running water.

'Our Atlantic ocean presents all the indications of a *valley*. It is as if a flow of eddying waters had been directed first towards the north-east, then towards the north-west, and back again to the north-east. The parallelism of the coasts north of 10° south latitude, the projecting and receding angles, the convexity of Brazil opposite the Gulf of Guinea, that of Africa under the same parallel, with the Gulf of the Antilles, all favour this apparently speculative view. In this Atlantic *valley*,' &c.

This beats *me*. This *is* 'aqueous denudation' with a vengeance. 'Ye gods, it doth amaze me that such a man as this should so get the start of the majestic world.' Three swoops, and the *valley* is complete. I wonder where 'the flow of eddying waters' came *from?* and I wonder where the *solid rocks*, which formerly filled this little *valley*, were washed *to?* Some day, I suppose, a mountain,

* Humboldt says ('Cosmos') 'the eruption of quartzose porphyry overthrew with violence the first great vegetation, from which the material of our present coal measures was formed.'

or chain of mountains, a cordillera, or tierra or sierra Humboldtiana, will be discovered, equivalent in size to the surface and depth of 'our' Atlantic. I think Humboldt is too modest here; he should call it *my* Atlantic. The surface of 'our' Atlantic is about twenty-five millions of square miles, and *unless it was a sea before it was formed into a sea,* it must have been surmounted by a continent when it fell a victim to the 'eddying waters.' Besides, therefore, the depth of the sea, the height of the old continent must be added to the new one.

Theoretically, the formation of this particular continent, the Tierra Humboldtiana, would differ from that of continents in general. For they, according to Humboldt, 'were formed by the *fusion* of separate, smaller continental masses.' Practically, the difference of formation would be found great indeed. For this huge heap would be formed by the *confusion* of vast masses of disrupted rock, which would clearly distinguish it from all boulder drifts and alluviums, and from all continents of stratified beds. Aqua fortis must have been the water of those days, or it could never, at a swoop, have torn up these solid rocks to the depth of 30,000 feet.

It is lamentable to find an Englishman imposed on by such bombastic trash. Keith Johnston, in his Physical Atlas, says 'the Atlantic ocean occu-

pies the great longitudinal *valley*, extending,' &c. If this is not an abuse of terms, we may say that three quarters of the surface space of the globe are occupied by one *valley*, and that the Pacific, Atlantic, Arctic, Antarctic, Indian, China, Mediterranean, Black, White, Yellow, Red, Baltic, Caribbean seas, with all their innumerable gulfs, bays, straits, and rivers, are only parts, particular nooks, corners, and *lanes* in this one *valley*. That the valley of the Thames is part of the same valley as the China sea and the Yang-tse-Kiang.

What a valley *is*.

In my view, seas are no more valleys than valleys are seas. Valleys are subaerial hollows, and not subaqueous hollows. A valley is, in my view, a waterslope, and this waterslope must be *continuous* to the sea, or to an inland lake. If you overstep a ridge which separates two waterslopes, I think you overstep the border of two valleys. Thus, if you stand on the chalk of the North Downs, south-east of London, where the Medway passes through them, and look to the chalk of the Anglian heights, east of Cambridge, when north of the Essex heights, you overstep the *valley* of the Thames, though you are still within what is absurdly called *the basin* of London. The *valley* of London would be the *valley* of the Thames; but the *basin* of London is quite another affair, and is no *valley* at all. The north-east half of the *basin* of London is out of the *valley* of the Thames, and the north-west

half of the *valley* of the Thames is out of the *basin* of London. The *basins* of London, Paris,* and Hampshire, have no relation whatever to *valleys*, river-courses, or *basins*. They only refer to those parts of these neighbourhoods which *are still undenuded*, and covered with tertiary strata, and these strata pass over hill and dale, and are not, as is usually stated, patches deposited in hollows. The origin of this opinion is twofold. First, some author has dubbed these tertiary regions *basins*, and his readers have naturally supposed that the *basins* are *hollow*, which they are not. Second, tertiary strata being frequently of soft material, are easily denuded from ridges and declivities, and remain only on those heights which are flat-topped, or table-land.

The *basins* of London, Paris, and Hampshire are not *valleys*.

The hollows formed in the original igneous elevation of land above the sea are infinite and innumerable. But they are not valleys. Water instantly occupies them, and turns them into seas or lakes, or fills them with drift and alluvium, or *transforms* them into valleys. That is, the moment any part of the bed of the sea is raised, rain shapes it into ridge and furrow.

* The Paris *basin* runs nearly 200 miles from north to south, and passes *over* not only the *heights* which divide the *valley* of the Seine from the *valley* of the Loire, but it passes and includes the Loire and the country south of Orleans, even as far as Sancerre, so that the Seine and the Loire traverse the same *basin*, one to Havre, the other to Nantes. But because tertiary strata must be deposited in '*depressions of the chalk*,' gentlemen of the closet join together these two distinct and magnificent river *valleys* and call them one basin.

If England and Ireland were raised so as to lay dry the part of the sea between them, this hollow could not be claimed as formed by running water. But though running water had not *formed* the *one* hollow, it would immediately *transform* it into two valleys. From some middle part the waters would flow in opposite directions to the sea. They would instantly fill all minor hollows with water, and gradually with drift and alluvium, at the same time wearing down the sides of the hollows next the sea, and would continue for ever to deepen these *two* valleys from the sea upwards. The cross ridge, from which the waters flowed north and south, being least exposed to the wash of rain, that is, having no accumulation of wash from above it, would *increase in height* in comparison with the *depth* of the valleys, and would as much divide the *one* hollow into *two* valleys or waterslopes, as the heights between the sources of the Mississippi and the St. Lawrence divide the valley of the Mississippi from the valley of the St. Lawrence.*

Laterally, each cliff which had been kept a precipice by the action of the sea at its foot, would instantly begin to accumulate a talus there, and,

* Keith Johnston talks of 'the plain of the Mississippi-Mackenzie.' He might as well talk of the plain of the Rhine-Danube, the centre of which plain would be the *plain of the Alps*. This would be childish enough, but in the case of the Mississippi and Mackenzie the vast valley of the Sascatchewan containing 360,000 square miles runs between them, from the Rocky Mountains to Hudson's Bay, at right angles to the so-called '*plain* of the Mississippi-Mackenzie.'

directly as its softness, the cliff would be changed into a sloping hill-side by disintegration and the wash of rain. For as long as the sea acts on the foot of a cliff it remains a precipice; because the undermining water acts more rapidly than disintegration and *wash*, and clears away all that falls. Abstract this power, even by the accidental accumulation of a bank of *travelling* shingle, and the cliff has a tendency to conform to the slope of the hill above it, that is, to the *wash* off the hill above it, both at the brow of the cliff and at its foot. For what is washed down the hill and off its brow will lie at the foot of the cliff as a shelving bank, and what was the mid-cliff gradually becomes the sole cliff. But this will eventually disappear into one slope.

If the top of the cliff is table-land, or slopes *from* the cliff, the cliff will waste much more slowly by disintegration and the action of the elements. But supposing such a cliff to be all of the same material, I think the brow has a tendency to disappear most quickly, possibly from a freer access and action of rain-water in disintegration, and possibly also from roots inserting themselves in crevices, and by turgescence detaching blocks bodily. Besides this, roots in decay generate carbonic acid, which is a great disintegrator. Another reason may be that the wash from above, which erodes and degrades the brow, is shot clear of lower parts, as in the case of a waterfall.

In addition to this, the entire surface of these former cliffs and present hill-sides would be laid in ridge and furrow. They would be grooved throughout by rain with small incipient valleys.

And if it may be said that the apexes and ridges of mountains are not formed by rain, I answer that they are at least *transformed* by rain. That is, their surface *is* formed by rain. The mountain top and brow are the very places to see this universal artificer begin his work. The longitudinal trunk river valley expatiates into as many myriads of *valleylet* extremities as a tree does into leaves; and if we pursue its leader or any one of its side branches to the end, that end is on the mountain-*top*. In porous subsoils indeed the *river* does not go near the top, but the *rain valley* does. But whether the landscape be savage or serene, water is the artist who painted it. Water formed the subjects alike of Salvator and of Claude. It is to water that we are indebted for the features which enchant us, whether we linger mid 'the dread magnificence' of Alpine ravines or gaze entranced from Windsor Terrace over

——— that schoolboy spot
We still remember, though we're there forgot.

CHAPTER XIV.

MAN MAY HAVE EXISTED IN THE SILURIAN PERIOD.

FOSSILS ARE CONSIDERED A PERFECT CATALOGUE OF SPECIES WHICH HAVE EXISTED. THIS SUPPOSES A WASH FROM THE WHOLE SURFACE OF THE EARTH INTO THE SEA. POSSIBILITY THAT COAL MAY BE ALWAYS FORMING. DRIFT AND ALLUVIUM, OR '*DEPOSIT ON DRY LAND*.' THESE *MODERN* BEDS CONTAIN *EXTINCT* ANIMALS. THE SAME FLOODS WHICH FORM THE DRIFT BEDS STOCK THEM WITH LAND ANIMALS. MAMMALIA AND MAN *MIGHT* HAVE EXISTED IN THE SILURIAN PERIOD, *FOR WHAT WE KNOW*. A CREATION WITHOUT CREATURES. DENUDATION AND DEPOSIT PERVADE THE WHOLE TERRAQUEOUS GLOBE. BUT NO STRATUM CAN BE UNIVERSAL OVER THE GLOBE. AS ALL STRATA HAVE *LAND* FOSSILS, ALL STRATA HAVE BEEN FORMED FROM THE DEBRIS OF LAND. THAT IS, BY SUBAERIAL NOT SUBMARINE DENUDATION. SURFACE FLINTS THE RESIDUUM OF DENUDATION. ORIGIN OF CHALK. ORIGIN OF FLINTS. STAINED SURFACE OF FLINTS.

Fossils are considered as a perfect catalogue of species which have existed.

ALL geologists argue as if the organic remains found in strata were a *perfect* history of the different species of animals and plants which have in succession existed on the globe from the beginning. But how can this be, unless there is now, and for ever has been, a wash from the surface of the earth into the sea?

This supposes a *wash* from the whole surface of the earth into the sea.

Humboldt says, 'the fossiliferous strata contain entombed within them the floras and faunas of bygone times.' In regard to 'vertebrated animals,

the most ancient of these are, as we have already seen, fishes; next in the order of succession of formation, passing from the lower to the upper, come reptiles and mammalia.' After enumerating the strata from the most ancient to the most recent tertiary beds, he says, 'then follow in the *alluvial* beds the colossal bones of the mammalia of the *primitive* world.' In the summary he alludes to the 'colossal bones of *antediluvial* mammalia in the upper alluvium;' and later he alludes to 'the sudden destruction of so great a number of colossal vertebrata in the *diluvial period*.' Would he have us believe that there was no room for them in the ark? No admittance for Theria or Sauria beginning with Mega or Macro?

But though I accept this universal opinion of geologists as a testimony to the everlasting wash of the land into the sea, I cannot think that a *perfect* history of all the organisations which have existed would result, even if we could see every fossil which the earth contains.

Except lake deposits, all *strata* are formed in the sea. Now we might almost say that all remains of *land animals* must perish utterly before they can be imbedded in *marine* strata, or before their *casts* can be taken there in stone.

It is only natural that in strata formed in the sea, the fossils *in general* should be of fish or of sea animals and plants, and that fresh-water or land animals or plants should be *a most rare exception*. So in fresh-

water strata amphibious animals and fresh-water productions prevail; and in beds of drift and alluvium, or 'sediment deposited on dry land,' land animals and plants. Where *are* the fossil remains of *land quadrupeds* found? In cavern deposits, in drift and alluviums 'deposited on dry land,' in filled-up lakes, in bogs, or frozen up in polar regions. Now all these land museums are not only modern, but they are superficial and temporary. They are liable to be washed into the sea; and their fossil contents *must be* destroyed before they can be redeposited in marine strata.

We have no museums for the collection of *really ancient* land existences. Marine strata are the museums for the collection of *really ancient* life; but their collections are very imperfect, except of those beings which wear their skeletons outside them. For it is not only that the external skeletons of shell-fish are infinitely more durable than internal skeletons, but the habits of the creatures make them, as they say, *safe* to be imbedded. If land animals had only a millionth chance of permanent imbedding which shell-fish have, what Theria Cruickshanksiana and Sidebottomi we should behold!

'As weak as water' is the common saying; yet water, in the form of rain, destroys old continents, and in the form of mud water builds new continents.

That land should flow *out* to sea is as paradoxical, and appears as impossible, as that water should go *up* through the air. Yet both these impossibili-

ties not only go on every day but all day long; and we *see* the water in the air as clouds, and the land in the water as muddy water. But it is *only* as muddy water the land goes *out* to sea, or as the finest sand. It is only as muddy water that the new emigrant continent takes passage to its destination. 'All the coarser material brought by floods to the shore remains there till the waves have ground it fine enough for carriage. 'And the waves they are never weary.' It is a large mill, and night or day never ceases to grind.

It is clear, however, that not a single bone of a land animal could be carried *out* to sea, except when a body, having sunk near the sea, rises again from putrescence and floats for a short time. But even in this case, except with an off-shore wind, the body would probably be cast ashore. Or an animal may be floated out on a tree, or on an iceberg, and if not devoured may become fossil. I need not go farther to show the impossibility that nature should write us a perfect catalogue of foregone *land animals* from such scanty materials, even if the archives which she has written were accessible to us. With regard to land *plants* it is otherwise. They might all float *out* to sea for great distances; that is, till they are *water-logged*, till water has replaced the air which they contain.

Possibility that coal may be always forming.

To this provision we owe our coal-beds; and I think it somewhat puzzling that coal should be con-

fined to the Paleozoic strata. On the west coast of Africa, immediately to the north of the equator, the Niger discharges from the mouths of its delta vast quantities of drift wood; immediately to the south of the equator the Congo does the same; and I have been told by merchants, and by officers serving on that coast, that islands of wood with trees *growing* on them float out to sea from both these rivers. The admirable Rennel has chalked out for us the course of the current which must convey this drift vegetation across the Atlantic to the Gulf of Mexico. We have all heard of the vast rafts formed in the Mississippi from the accumulation of drift timber. We have all heard of the enormous quantities of drift wood discharged from the mouths of the Amazon, the Orinoco, and the tropical rivers of the north part of South America. What becomes of these vast magazines of carbon till they are so waterlogged as to sink? Probably, as Lyell remarks, a large proportion takes passage by the Gulf Stream. And not improbably, vast beds of future coal may now be depositing in high *northern* latitudes, the greatest part of which may be composed of *tropical* plants. The tropics of the old world, as well as the new, are most probably at this moment storing their superabundant vegetation for the future warming of our northern descendants. If this is true, coal *may* be found in any stratum foregone or to come.*

* Note to Third Edition.—As regards floatage of timber, I should

Drift and alluvium, or '*deposit on dry land.*'

Lyell heads a paragraph with 'No sediment on dry land,' 'Principles,' chap. xiii. What then is the entire deposit of all alluvial plains? and of that part of all deltas which is above the level of the sea? Rivers may flow through alluvial plains for a continuous distance of hundreds, nay thousands, of miles from the sea, the whole of which alluvium has travelled there as *muddy water*. That is, every particle of the nearly flat surface has been held in suspension by the flooded rivers and deposited by them 'on dry land.'

I should also ask, what then is *drift?* Lyell would account for these beds as the remains of his favourite *submarine* denudation, previous to the elevation of the land. If so, why are they so full of the fossil remains of *land* animals? and how does the *submarine* theory apply to the drift bed near Behat, in India, mentioned in the ninth chapter, which,

have laid more stress on currents of air and less on currents of water; that is, on the south-east trade winds of the south tropic for the equatorial current, and on the south-west winds of the north temperate region for the gulf stream. Certain it is that the Norwegian and the Laplander of to-day warms himself with drift timber from the West Indies, and that tropical timber is heaped to great heights on the shores of Spitzbergen, where there is no man to consume it. This heaping could not happen from a current of water, but solely from the impact of waves derived from the wind. The same cause, floatage driven by the wind, would account for tropical vegetation in Arctic strata without need of equatorial climate at the North Pole. Throw a handful of leaves or sticks into the Serpentine on the windward side, they will soon be landed on the leeward side. This is not owing to a change of climate or to the gulf stream.

Captain Cautley tells us, was deposited 'within the memory of persons now living'? And how does it apply to the bed which covers the 'very ancient subterranean town' there? Was the present *subterranean* town formerly a *submarine* one? 'In sinking wells in the environs, masses of shingle and boulders have been reached resembling those *now* in the river channels of the same district (so we see how long the game which is *now* playing has been going on) *under* a deposit of *thirty feet* of reddish loam. Captain Cautley, therefore, who directed the excavations, supposes that the matter discharged by torrents *has gradually raised the whole country skirting the base of the lower hills.*'

As these are quotations from Lyell's own 'Prinples,' may I not again ask, in his own words, if 'a false theory does not render him blind to facts which are opposed to his prepossessions, or conceal from him their true import when he beholds them?'

I only mention these particular beds because the account of them may be easily referred to by the reader. But the beds of drift, in general, are of enormous extent, and are not confined only to the alluvial neighbourhood of rivers and their estuaries, or even to low lands, but are found on very high lands provided they have higher land, or have had higher lands in their neighbourhood. High steep places waste comparatively rapidly on to lower and less steep places. Low flat places waste compara-

tively slowly into the sea. But, except on the brow of a hill, when a geologist states the arrangement of the beds of any district, the following is almost invariably his exordium :—

1. Vegetable mould.

2. Alluvial gravel, loam, clay, &c. (that is, 'sediment deposited on dry land').

3. The upper layer, which has been deposited not only *by* water but *in* water.

Our rivers are considered to be perpetually existent, though their component waters are perpetually in transitu. The same may be said of the rich soil of our valleys, though the change here is infinitely more gradual. Infinitely more gradual still is the change of our drift beds. Indeed, in some places their denudation would require a time which, compared with the existence of any species of animal, might be called an eternity. For instance, in the case of bags or cavities without outlets, formed in the original igneous elevation of the land, or of vacancies and crevices and faults formed by earthquakes or landslips, or unequal subsidence of upheaval, or of a talus at the foot of a precipice, or any place which required filling in and embanking in the formation of the aqueous gradients which drain the entire superficies of the existent earth (and this head would comprehend enormous areas), these spaces would all be occupied by drift, formed, as the scientific would say, by 'the surface débris,' or, as the common

people would say, by 'the run of the hill;' and they could only be denuded at the same pace as the surface of the old strata above and around them.

These *modern* beds contain *extinct* animals.

And though these beds are considered geologically *new*, and indeed some of them were formed yesterday and some are forming to-day, they are not all so new but what the English beds of them contain remains of species long since extinct on earth, as the mastodon or the mammoth, the gigantic mole, and of animals which have long since ceased to inhabit these climes, as the elephant, rhinoceros, hippopotamus, buffalo, bison, Irish elk, reindeer, tiger, leopard, hyæna, bear, wild boar, wolf, beaver, monkey, lagomys, &c., besides animals which still do exist here, as the horse, ass, deer, ox, roebuck, otter, badger, fox, the wild cat, goat, &c.

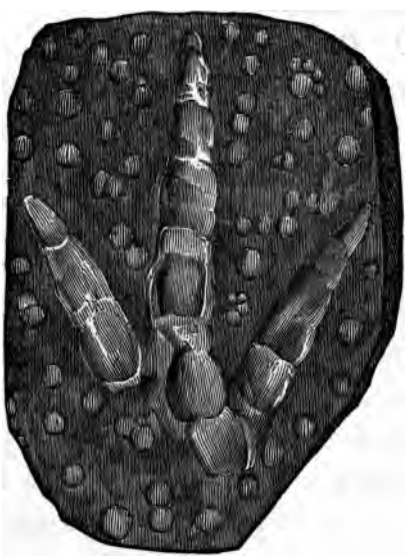
The same floods which form the drift beds stock them with land animals.

Death in general does not play the sexton, but leaves his victim to be devoured by animals or to be reproduced in plants. Floods bury a great part of the slain, *and the same floods which form the drift beds stock them with land animals*, and except as exceptions, these '*deposits on dry land*' are the only spots where we *should* find fossil *land animals;* and to argue that no *land* quadrupeds (or if you will have a fine word, mammalia) existed during the period that any or every *marine* stratum was deposited, on the negative evidence that no fossils of them are found there, is ridiculous. And because we happen on beds stored with fossils of amphibious creatures and

gigantic lizards, to assume that the whole earth, from the denudation of a part of which these beds were formed, supported no other animals, and therefore to talk of 'the age of reptiles,' is equally ridiculous. Similar reptiles, fresh-water and marine, are imbedded every day *now* in the alluviums of Asia, Africa, America, and Australia, yet we flatter ourselves that gavials, koomiahs, muggars, crocodiles, caymans, and alligators are not the sole possessors of the globe; nor are they at all a prominent feature among organic existences.

In the Triassic strata, the *footmarks* of numerous species of birds have been found. Imagine the chances against these footmarks being *preserved!* and imagine the chances against their being afterwards *discovered!* One species is supposed to have been four or five times larger than our largest bird, the ostrich. Dr. Deane, quoted by Mantell, 'Wonders of Geology,' p. 558, says: 'I have in my possession consecutive impressions of tridactyle feet which measure eighteen inches in length by fourteen in breadth, between the extremities of the lateral toes. Each footstep will hold half a gallon of water, and the stride is four feet. The original bird must have been four or five times larger than the African ostrich, and therefore could not have weighed less than 600 pounds. Every step the creature took sank deep, and the substrata bent beneath the enormous load. If an ox walked over stiffened clay, he would not sink so

deeply as did this tremendous bird.' Mantell adds, 'Mr. Lyell mentions having seen on the banks of the Connecticut river (at Smith's Ferry, near Northampton, eleven miles from Springfield), a space several yards square, where the entire surface of the shale was irregular and jagged, owing to the number of footsteps, not one of which could be traced distinctly, as when a flock of sheep have passed over a muddy marl; but on withdrawing from this area, the confusion gradually ceased, and the tracks became distinct. Some fine slabs of the sandstone covered with several tracks of bipeds of various sizes, collected by Dr. Deane, are deposited in the British Museum. A representation of one of the small im-



FOOTMARK OF A BIPED, AND IMPRESSIONS OF RAINDROPS, on Sandstone; Massachusetts (*nat. size*).

prints of the natural size, with the surface of the stone marked with hemispherical pits produced by a shower of rain, is given.' Yet no other traces of any bird are found in the Triassic, or in any strata between them and the tertiaries. Will anyone conclude that birds became extinct and did not exist on earth between the Triassic and tertiary period, on the negative evidence that no traces of them are found? Why, then, on this negative evidence, conclude that birds did not exist *before* the Triassic period, even in the Silurian? The largest land quadrupeds, nay man himself, *might* have existed in the Silurian period *for aught we know geologically*. To suppose the reverse, to suppose with Humboldt that the land was uninhabited during the countless myriads of ages when fish were being entombed in the ancient, secondary, and tertiary marine strata, is in fact to suppose a creation without creatures, that for what man may call 'an eternity of time' this *earth* has swung tenantless through space, an inorganic desert, rotating each day before the sun and each year round the sun. Can this creation of inanimate desolateness be supposed?

Mammalia and man *might* have existed in the Silurian period *for what we know.*

A creation without creatures.

We discover now the ruins of civilised empires of which history gives not a hint. For instance, in Cambodia and in America, the so-called *new* world. How many civilised empires then *may* have existed of which etiam peruere ruinæ? This on our actually existent continents. But, as Beattie writes, 'Where

the Atlantic rolls wide continents have bloomed,' and empires of civilised men may have flourished on these wide continents for 'an eternity of time.'

I have already mentioned, however, the exceptional appearance of land quadrupeds in the Oolitic strata, and their reappearance in the comparatively modern fresh-water tertiary beds. Did they vanish from the earth between these periods, or might they not have existed before? Myriads of species of megatheriums, macrotheriums, dinotheriums, anaplotheriums, or *anyothertheriums* may have existed *before* the Silurian or primary and metamorphic period, without a vestige of their fossil remains being found in these strata. Their fossil remains would have been hoarded in the drift and alluvium of the lands from the denudation of which the Silurian and metamorphic beds were formed, and the fossil remains would have been dissolved pari passu with those ancient continents.

Denudation and deposit pervade the whole terraqueous globe.

Denudation and deposit pervade the whole terraqueous globe. That is, the whole surface of the land is perpetually denuded, and the whole bed of the sea perpetually deposited on.

But no stratum can be universal over the globe.

But I need not remark that it is impossible that any stratum should be continuous over the globe, since those continents could not be deposited on whose denudation furnished the deposit. As three quarters of the surface of the globe are now sea, those three quarters might be subject to deposit now.

About the same proportion may always have obtained. That is, we have no reason to suppose but what the globe is now, and ever has been, pretty much the same as when God first created it.

As all strata have *land* fossils, all strata have been formed from the débris of *land*. That is, by subaerial, not submarine denudation.

But though fossils of *land* animals are rare in *marine* strata, we are not *totally* without the olive branch *anywhere*. There are unequivocal symptoms of neighbouring dry land in *all* strata. Even not excepting the chalk, all deposited strata do occasionally contain the remains of *land* animals, plants, or shells; or of *river* animals, plants, or shells; or they have ripple-marks or footmarks. If this does not prove that the entire masses of these strata were deposited from the subaerial denudation of land which was high above the sea, it at least proves that while these beds were being deposited they were within the *reach* of high land which was suffering denudation.

I have inserted ripple-marks in my list of witnesses, because they form almost my only claim to the Silurian and crystalline and altered beds. Ripple-marks, however, evidently testify the neighbourhood of land while the ground on which they were imprinted was subject to deposition. Had the ground on which they were formed been rising and subject to denudation, they would have vanished.* With regard to the remains of land plants, Lyell ('Prin-

* In 1875 Batnachia were discovered in Paleozoic strata. They were not supposed to have existed till tertiary times. Some of these days we shall be startled by the imprint of 'Man Friday's' foot in Cambrian sandstone. Note to third edition.

ciples') says of the Silurian beds: 'Hitherto few, if any, contemporaneous vegetable remains have been noticed; but such as are mentioned agree more nearly with the plants of the carboniferous era than any other, and would therefore imply a warm and humid atmosphere, entirely free from intense cold throughout the year.' According to Playfair, ripple-marks are found in the crystalline and altered rocks.

In reference to the chalk, it is entirely exceptional. It is a deep-sea deposit, not resulting from *any* denudation, but formed of the calcareous parts of the remains of fish, corals, zoophytes, and animalculæ, as its flints are of the siliceous parts of these remains. And I think that this accounts for 'the hiatus which still separates the cretaceous and Eocene periods in Europe.' For it is only natural that the organic remains of the deep-sea deposit should differ from those of deposits formed from the detritus of land.

Surface flints the residuum of denudation.

In chalk countries denudation leaves a *residuum* of flints on the surface; because, though these flints disintegrate, and though each of them is surrounded with a white soft surface of decay, they do not decay so fast as the chalk. Notwithstanding the most sedulous *stonepicking*, these flints still make their appearance, and it is the universal opinion among farmers that they *grow*, not in size, but in numbers. But however we may laugh at the idea of the *growth* of flints on land, for the *fact* that surface flints increase in number it is impossible to suppose more

competent witnesses than farmers; and how is the *fact* to be accounted for unless they are the residuum of denudation? When sheep, in feeding off turnips, have trodden the ground firm and the flints loose, I have seen them raked into rows and shovelled into carts. And were it not that the bulk of the layers of chalk which decay into soil so infinitely exceeds the bulk of the layers of flint which decay into soil, the accumulation of surface flints would soon stop agriculture in chalk districts. But as rain gradually and annually washes away the soil, the plough brings up fresh flints. And this increase of surface flints in number would prove a very universal denudation going on at this moment under our own eyes. I add this paragraph to the second edition:—With regard to the formation of chalk, we have pretty good evidence that it is *now* forming on an enormous scale. In the Atlantic, Lieut. Nelson found a deposit from decayed coral in some lagoons at the Bermudas, some specimens of which are now in the museum of the Geological Society, and Lyell says that they are only to be distinguished from chalk *by their labels*. In the Pacific, Darwin says that myriads of fish of the genus Sparus feed day and night on the living corals on the outside of the reefs, and that the inside parts of the reefs are perforated in all directions by a certain worm, and that the excrement of the fish and of the worm is not to be distinguished from chalk. Now, as there are many, many thousand

Origin of chalk.

Origin of flints.

miles of coral reefs, we need not look farther for the origin of chalk. With regard to the *how* flint was formed, I think that all the suppositions are the merest and sheerest *guesses*. But I think that the *when* and the *where* are clear as far as this, that flint was formed *when* the chalk was formed and *where* the chalk was formed, because flint fills and involves the shell-fish and zoophytes of the chalk sea. I think that it is clear that both the chalk and the flint were formed *in* the sea, and I should *guess* that *out* of the sea (that is, after the chalk was raised) there has been no change whatever in either of them except *decay*. And I add this paragraph to the third edition:—The decaying surface of flints is very easily stained by water impregnated with iron. Hence our yellow and red gravels. When these are exposed to the atmosphere, decay of the surface goes on, and the gravels are blanched. The practical philosopher, the gardener, then *turns* the gravel, and again presents a coloured surface for the atmosphere again to blanch. Humboldt, in Cosmos, talks great nonsense about the intense heat necessary to alter the surface of our *so-called* aerolites. The alteration is simply the effect of the same cause which alters the surface of the flint, the chemistry of moisture and the atmosphere.

Stained surface of flints.

CHAPTER XV.

ELLET ON THE MISSISSIPPI.

ELLET FORMS THE ALLUVIAL PLAIN SOLELY *FORWARD* AND SOLELY IN THE SEA. THE BEDS OF RIVERS AND VALLEYS ARE FORMED CHIEFLY *BACKWARD* OR *UP* THE VALLEY. RIVERS MAY HAVE PATCHES OF ALLUVIAL PLAIN ANYWHERE. AND THESE PATCHES *PROGRESS BACKWARD*, OR *UP* THE VALLEY. THE PRACTICAL MAN'S *MONSTROUS* THEORY OF THE FORMATION OF THE DELTA. IF THIS THEORY WERE TRUE, THE RIVER ONCE EMBANKED WOULD BE ALWAYS EMBANKED. BUT ETERNAL CAUSES NECESSITATE AN ETERNAL RAISING OF THE EMBANKMENTS. PRINCIPLE OF THE LONGITUDINAL AND LATERAL SLOPE OF ALLUVIAL PLAINS. THE BED OF THE RIVER RISES WITH THE ALLUVIAL PLAIN. WHY ALLUVIAL RIVERS RECEIVE TRIBUTARIES WITHOUT INCREASE OF WIDTH. CAUSE OF THE SHAPE OF DELTAS. THE PARADISE FOR MAN IS FORMED BY RAIN AND RIVERS.

THE second edition of the 'Tree-lifter' was scarcely printed before Ellet's work on the embankment of the alluvial part of the Mississippi came into my hands. His views of the mode of formation of alluvial plains differ widely from those which I have stated in the 'Tree-lifter,' 1853.

This practical man abjures and bars '*geological speculations*,' and at the same moment that he abjures these, he brings forth geological speculations of a character more monstrous than any which have been perpetrated in modern times. But, doubtless, Ellet's opinions are practice, and his neighbour's opinions

'speculations.' This is a very usual and very useful definition of the difference between theory and practice.

Ellett forms the alluvial plain solely *forward*, in the sea.

Ellet calls the whole of the alluvial plain the delta. I should restrict the delta to that small part of an alluvial plain from the sea to where the river first breaks into branches to the sea, the two outside of which, with the sea shore, often form a Δ. I do not, however, fight about a name, nor should I if it was the hardest and longest that Humboldt ever coined. But Ellet makes 'the head of the delta' and the line of the ancient sea shore the same, and he places these as far north or up the river as Commerce, above the Ohio. I should place the line of the ancient shore at least as far south as the present shore east and west of New Orleans. Ellet, indeed, deprecates the mooting the question, and designates it as 'an irrelevant geological speculation.' But, as will be seen by the diagram, page 233, Ellet forms his delta solely *forward* and solely in the sea. And according to him and his diagram, it is only the sea-formed delta which rises. From the sea shore upward or *backward*, the level of the land-formed alluvial plain has been stationary for 45,000 years! It is therefore of vital importance even to Ellet's extraordinary theory, to know which part of the plain is sea-formed, and which is land-formed, that is, where the ancient sea shore ran. I shall refer to this question hereafter, and shall here endeavour to show that all alluvial plains, including their deltas, increase

and rise every year everywhere, *backward* up the valleys, as well as *forward* in the sea, at the ends of the deltas.

The beds of rivers and valleys are formed chiefly *backward*, or *up* the valley.

Rain, or a river, works at the whole length of the valley or river course at the same time. But the *chief* formation is *backward*, that is from the sea to the hill. For, as the beds of rivers, if not horizontal, slope *down* to the sea, it is evident that the cutting down of the parts farthest from the sea must depend on the cutting down of the parts nearest the sea; that is, the parts farthest from the sea cannot be cut lower than the parts next the sea. So far the cutting of the parts farthest from the sea is dependent on the cutting of the parts next the sea. So that the *chief* longitudinal cutting of a valley or river-bed may be said to proceed from below upward as regards the valley, or *backward* as regards the stream of the river; that is, it proceeds from the sea to the hill, not from the hill to the sea.

No one will doubt that the Niagara gorge is cut *backward;* but take the case of a barrier without a lake behind it. Suppose a barrier of rock to run across any valley or river-bed; when the bed of the valley or river on the upper side of the barrier has been worn down to a horizontal level with this barrier, it can *not* go lower. The barrier is in this particular case what the sea is in all cases, a negative key to the level of the valley. Thus deep shalt thou go and no deeper. A river-bed cannot run down

before it comes to the barrier, and then again over the barrier. But as the barrier is cut through, the bed of the valley or river will be deepened *backward*, or from below upward, or towards the hills. This principle is true of the *filling in* of valleys as well as of the *scooping* them *out*. For when the scooping out or deepening is stopped at the lower end by the sea or a barrier of rock, denudation of the inclined parts above still goes on, and makes that lower part horizontal. And the passage of the detritus and soil from the inclined upper parts of valleys is checked in the horizontal lower parts of valleys, and soil accumulates there. This is the origin of alluvial plains; and a river of any size, or any rapidity, may, at any distance from the sea, have *patches* of alluvial plain, where no lakes have ever been; that is, above every rapid or accidental barrier of hard ground. For as the barrier ponds the flood-water back on the horizontal valley above it, deposit will take place, that deposit will increase the ponding back *up* the valley, and, as long as overflow takes place, these patches will rise and *progress backward* up the valley. The only difference in the laws for the growth and gradient of these patches from those which regulate the growth and gradient of the plain at the level of the sea, is that they have no *increasing* cause for rising equivalent to the *forward* lengthening of the delta of the lower alluvial plain.

Rivers may have patches of alluvial plain anywhere,

and these patches *progress backward*, or *up* the valley.

These flat alluvial patches may be seen even in

torrents, sometimes reaching from one cascade to the other; and though each cascade digs a hole deep in proportion to the height of the cascade, as the cascade recedes, that part of the hole or rather groove which is farthest from the cascade is filled with débris. It is easy to perceive that these patches must be liable to constant change. They must be perpetually shortened by the recession of the lower barrier, and lengthened by the recession of the upper one: also that the wearing down of a barrier or shallow from below will expose the alluvial patch above it to denudation; while the rise of an alluvial patch from below, over a rapid above it, may join two alluvial patches in one. These principles are eternally at work on all valleys, from the smallest to the largest.

With regard to the lower alluvial plain, the last yard protruded *at* the level of the sea, by preventing the flood-water spreading in the sea, that is by ponding the water *back*, forces it *over* the yard *behind* it, and raises that yard *above* the level of the sea; and so every yard raises the yard *behind* it *backward* in succession not only to the highest point of the alluvial plain, but above it; that is, from the end of the delta at the sea, the river builds its alluvial plain at a certain gradient (say that given by Ellet, eight inches in a mile), and its banks, say at a gradient of three inches in a mile,* till these gradients strike the un-

* The difference is owing to the winding of the banks through the plain.

alluvial bed, which it progresses *up;* and whether the whole river is artificially embanked, or whether it has patches embanked, in either case, the banks must eternally be raised with the eternal rising of this *natural* gradient.

Thus it is that a river is enabled to build itself a channel of indefinite length out to sea (the Ganges runs 220 miles out to sea), the sides of which channel shall not only confine for three parts of the year, the waters which build them, but these banks shall rise high above the level of the sea through which they are built, and shall attain, on the alluvial plain, to the height of 300 feet in 500 miles, though the river which builds them is the very power which excavated their foundations. All this appears impossible: yet every day, in every quarter of the globe, these impossibilities are being performed.

The height of banks thus built above the spring-water, is simply the difference between the level of the flood-water and spring-water. The difference between the level of the flood-water and spring-water at the sea is nothing. Therefore the banks die off to nothing at the sea. And one would suppose that there must be a fixed rule for the height of alluvial banks, according to the distance from the sea. In other words, that there must be a fixed rule for the increased rise of the flood-water necessary to overflow alluvial banks, directly as their increased distance from the sea. Though possibly this would chiefly

depend on the quantity and suddenness of the floods to which each individual river is subject. I have seen somewhere, I think in Herodotus, the planetary number 7 applied to the Nile, in the supposition that at Mendes it required a rise of 7 cubits to overflow the banks, at Memphis 14, and at Syene 28*. The rule however, if there be one, would only apply where the banks and bed are completely alluvial.† The deposits must also tend to die off to nothing at the upper end of the alluvial valley, unless the slope of the unalluvial valley is suddenly terminated by a ridge of rock.

This determination of valleys *to begin at the end*, and *to go on backwards*, is, as has been said, the cause why they are generally widest at the end next the sea. Because the *longitudinal* cutting being there first made, the sides will be there first exposed to disintegration and the *lateral* wash of rain. So that, other circumstances the same, valleys widen as they

* So published in the two first editions. The passage is in Plutarch's Isis and Osiris, section 43, where the numbers are made to refer to the quartering of the moon. Plutarch describes the annual growth of the delta upward on the land and forward in the sea from new deposit from the river in section 40: *Ὁρῶμεν γὰρ ἔτι νῦν ἐπιφέροντι τῷ ποταμῷ νέαν ὑλὺν καὶ προσαγαγόντι τὴν γῆν, κατὰ μικρὸν ὑποχωροῦν ὀπίσω τὸ πέλαγος, καὶ τὴν θάλασσαν, ὕψος τῶν ἐν βάθει λαμβανόντων διὰ τὰς προσχώσεις, ἀπορρέουσαν.*

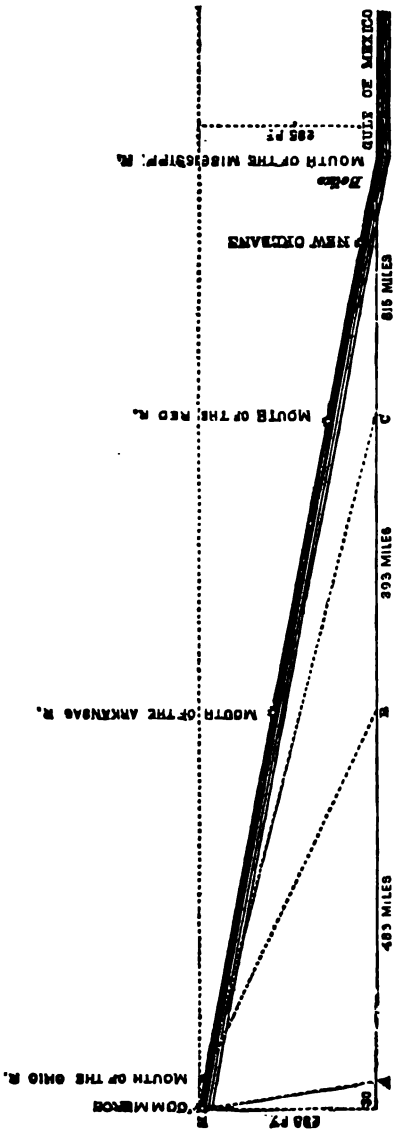
† As a loose approximation to a general rule, may it be said that the slope towards the sea of the banks of an alluvial river is between two and three inches in a mile, and that the slope of the flood-water is the same? I think that Ellet is wrong in laying down a rule for the low water slope; as long as the river is confined by its banks the slope must constantly vary. It must increase and decrease directly as the volume of water. So also must the velocity of the stream.

descend. But directly as the comparative hardness of the sides of any part of a valley will be the comparative narrowness of that part.

The practical man's monstrous theory of the formation of the delta.

Ellet has left the main *natural* difficulty out of the calculation. That is, he has blinked the growth of the alluvial plain *backward up* the valley, *on the land.* To suit his mode of forming the delta only *forward,* and *only in the sea,* he introduces the sea (and a deep sea too) 500 miles into the Continent of America, up 'to the village of Commerce, about thirty miles above the mouth of the Ohio.' 'It is not an unreasonable supposition that, at periods anterior to the commencement of the deposit, the bed of the gulf sloped up uniformly from its present depth ('more than 1000 feet') near Belize to the shores then found above the mouth of the Ohio.'

Here he tumbles the Mississippi over a cataract at 'the point at which rock *in situ* is first encountered on both sides of its channel, and supposed to be found in its bed.' The cataract has 'a fall of 285 feet at low water, or nearly double the actual perpendicular descent of the falls of Niagara.' And the same rock still remains '*in situ*' in the channel of the river over which this cascade rolled for 45,000 years, while it formed the delta. And the wear and tear, not only of the floods of the river, for this space of time, but the passage of the material of the entire alluvial plain, have neither lowered the rock a hair's breadth, nor caused its face to retreat an inch



Ellet's notion of the successive and progressive formation of the Delta of the Mississippi.

up the valley. Indeed, so far from any erosion being formed by this cataract, a curiously strong deposit, a sort of *cascade of deposits*, instantly begins from it. It builds up from the bottom of the sea, perhaps 300 feet deep, an alluvial deposit to the top of the cataract, nearly 300 feet high. This deposit, *retaining always the same level at the cataract*, is pushed *forward* in the course of 45,000 years to the end of the present delta. And 'the inevitable consequence of this hypothesis will then be that the slope of the plain must have been at successive periods, as represented.' 'The whole space embraced in the triangle H A B, became filled up by sedimentary accretions, and the river sloped off from H to the mouth of the Arkansas, with a descent represented by H B, more than twice as great as its present rate of descent.'

If this theory were true, the river once embanked would be always embanked.

If alluvial plains were formed according to this diagram, solely down stream, or *forward* in the sea, from the sea shore *backward* on the land, the river once embanked would be always embanked, and there would be no difficulty about it. But nothing in nature ever happened like this diagram. The left end of the line of deposits never got *up* to H before the right end arrived at D.

Ellet has only allowed for his house being on fire at one end, whereas it is on fire at both ends. He has only raised and lengthened the line of new deposits to the right, or *forward* into the sea, whereas nature raises it, and lengthens it to the left also, or

backward up the valley. And the present line of deposits, H D, is not *by nature stationary at* H, as Ellet has made it for 45,000 years, but would be for ever rising throughout, and lengthening at both ends, unless stopped for a time (in lengthening, not in rising) by the foot of a rapid to the left, above H, which it will progress *up*, while the water wears it *down*.

But eternal causes necessitate an eternal raising of the embankments.

Though artificial embankments will stop this rise of deposits altogether, and even expose them to denudation, the eternal causes of the rise of deposits will be at work on the rise of the surface of the river, and of its bed, and consequently on the necessary rise of the artificial embankment *for ever*. And as long as man *can* play this game, the plain, instead of *rising* every year from overflow and deposit, will *sink* every year from denudation, while the surface of the river and its bed will rise every year.

The *filling in* of valleys is, as has been said, on the same principle as that which governs their *scooping out*. That is, it proceeds chiefly from the sea towards the hill. And the *chief* growth of alluvial plains in extent of area is backward or up stream on the land, not forward in the sea. That is, it is simply from the ponding back and overflow of water, which must happen where valleys which have been worn horizontal, or nearly horizontal, receive the flood-water from the inclined channels of unalluvial rivers. Commerce is nearly 300 feet above the level

of the sea. The direct distance to the sea is about 500 miles. The slope of the land is about eight inches in the mile. By the river, the distance is about 1200 miles, the slope of the banks is about three inches in the mile. Cut off the lower 250 miles of alluvial plain, or introduce a deep estuary that distance, there would be a fall of the river into the estuary of nearly 150 feet. This would soon cut a deep channel through the soft alluvial deposits, *backward* to Commerce, and the river *could* not overflow and deposit on its banks. Clap on the lower 250 miles of deposits again, and it *will* overflow and deposit on its banks. Why? because the *lower* 250 miles of deposits pond the river back on the *upper* 250 miles of deposits.

Artificial banks prevent this rising of the plain, that is, of the *natural* banks. While, by *increasing* the *rise* of the delta in the sea, they *increase* the ponding back, or rising of the surface of the river and of its bed. Art, therefore, is not only perpetually fighting against itself, but perpetually increasing its powers against itself; that is, in the case of the Mississippi, the deposit which nature would annually spread over the surface of 40,000 square miles to raise the land against the water, art annually sends to the end of the delta to *increase* the rising of the water against the land, while at the same time it exposes that land to denudation.

Principle of

There are two slopes in perpetual formation in

alluvial plains. The degree of the longitudinal slope (eight inches per mile) is the result of the annual ponding back of flood-water. The degree of the lateral slope (say 40 inches per mile) results from the dying off of deposits from moving water. The longitudinal slope is so slight that to *almost* all *practical* intents it may be left out of calculation. But the effect of this slight difference between principle and practice, in such a basin as the Mississippi, may expose millions of men to the constant *chance* of death to themselves and destruction to their property from inundation, with the *certainty* that their *actual* estates are in process of becoming subterranean and themselves and their works fossil. For let the Po fill the Adriatic at a dead level, what signifies it to Ferrara? but give a slope of eight inches in the mile from Otranto towards the Alps, and Ferrara is subterranean.

the longitudinal and lateral slopes of alluvial plains.

When the Mississippi first began to cut its channel to the sea, which was when the land had just risen from the sea, there was no indenture in the sweep of the shore of the gulf, nor did that shore reach up to above the Ohio, as Ellet has supposed. On the contrary, the shores of the gulf (I do not allude to the delta) extended then much farther into the sea than they do now, and they have been worn back by the sea. But the line even of the present sea shore would cross the delta about New Orleans. And the very least that can be abstracted from Ellet's

ancient sea is the distance between New Orleans and Commerce.

This question is, as I have said, of importance, because, according to Ellet's theory and diagram, the level of the plain at the sea shore, and from thence upwards, is stationary, and it is only in the sea that the delta rises. And the rise of nearly 300 feet from New Orleans to Commerce is, according to Ellet, exceptional, as regards the plain above it, because it was raised in the sea. Whereas, in fact, it was raised on the land, by the same causes which are now raising it and all the alluvial parts above it. The only part of the delta formed in the sea is from New Orleans to the point D, in the diagram.

The young river made an indenture in the sweep of the shores; the mature river filled it in. The young river made an indenture as its estuary, or negative delta, as it is called, which must always precede a positive delta. For, as has been repeated *too often*, the direct operation of a river is only to cut down a deep channel for itself, till that cutting down is stopped by the sea. But since this estuary was cut, rain has formed the entire valley of the Mississippi, and the river has rolled the former contents of this valley into the sea. There is no wonder then at the *largeness* of the delta; the wonder is that it is so *small*. It is perhaps a millionth part of what has gone into the sea. And the other 999,999 parts

are now forming tertiary (or *quartiary**) strata, to support our descendants a million years hence. But small as the delta is, it is a pretty good lump of earth. And where does it come from, unless from the formation of the valley? But the operation has not ceased. On the contrary, it increases in vigour; and the river is not only now daily increasing the growth of the delta and the alluvial plain, by deposit from the denudation of the whole of its tributary *ground*, but the greater the future growth of this tributary ground, that is, of the unalluvial valley, in length and in width, the greater will be the supply, not only of water, but of alluvium, and consequently the greater will be the growth of the delta *forward* into the sea, and of the alluvial plain *backward* up the valley. If, according to Ellet's theory and diagram, the level of the plain upward from the sea shore, which he puts at Commerce, but which actually was at New Orleans, has remained the same for 45,000 years, it may remain the same for the next 45,000 years. This is a very comfortable doctrine because, in this case, the river once embanked is always embanked. But in fact, as has been stated, the level of a valley is never permanent in any part, and there is no part of the valley of the Mississippi

* I *used* this expression in 1857 before I ever saw the more euphonious 'quarternary strata.' And I have never yet seen this expression 'quarternary strata' except *misused*. That is, applied to surface drift and alluvium deposited on land instead of strata deposited in water.

subject to flood which is not raised by deposit every year, nor any part of the whole valley not subject to flood, or where flood *is banked* out, which is not lowered every year by denudation.

'Rock *in situ*' in the channel of a river is no proof *in general* that the sea reached up to it. The river may have cut any quantity of rocky strata down to *below* the level of its *present* bed between Commerce and the Gulf, and afterwards have covered them deep under the alluvial plain, as it may hereafter *the particular* rock at Commerce, or any successive strata of rocks higher up the river. And the Mississippi is now, and for ever will be, *going on backwards* up the valley, wearing *down* rapids and pushing *up* the alluvial plain, and patches of alluvial plain.

And as to *the particular rock* at Commerce, the river *has* evidently cut it down to its present level, out of the chain 'where the rocky hills approach the shore on both sides.' And Ellet's cascade would have originally fallen from the top of these 'rocky hills' into *his* sea, *if* it had existed.

Whether the river cut its passage through these 'rocky hills' by ponding, that is, by forming a lake behind them, like the St. Lawrence at Niagara, or without ponding, as the Weald rivers have through the North and South Downs, is probably now not to be guessed at. But the reason that these 'rocky hills' still 'approach the shore on both sides' is simply their hardness in comparison with the sides

of the valley, above and below. They have yielded less quickly to disintegration and the wash of rain, and therefore project from the sides of the valley, from the same cause as the volcanic dikes do from the sides of the Val del Bove.

If left to nature, the river might continue to erode its rocky bed at Commerce, and while this erosion was going on the alluvial plain might rise, and with it the bed of the river, and, passing clear over the rock, they might carry their uniform gradients up the valley for hundreds of miles. The first rock '*in situ*' above Commerce would then, according to Ellet, mark where the delta began and *the sea ended.*

Any stratum of rock which formed a barrier across the valley 1000 miles above Commerce might occasion a detached patch of alluvial plain above it. Below this barrier the river might run for 100 miles over rapids, and as the river wore this bed of rocks *down*, and the alluvial plain progressed *up* the valley, this patch of alluvial plain might be joined to the lower plain, and so become the beginning of what Ellet calls the delta.

The *bed* of the river rises with the alluvial plain.

Ellet contends against '*the popular belief*,' that the river raises its bed. He is constrained, however, to allow that it *has* done so, through the 500 miles of his own particular sea-formed delta. If it had not raised its bed between Commerce and Belize, the bed of the river now would be the same as the bed of Ellet's ancient sea; just inside the mouth of the

river there *should be* more than 1000 feet of water where there *are* now 100. And though the bed would 'slope up uniformly' to 'above the mouth of the Ohio,' we should then add 300 feet to the depth of the river, namely, the depth of the old cataract from 'the rock *in situ*.' Ellet, however, gives the depth of the river there as about seventy feet. Its *bed* then must be upwards of 200 feet above the *surface* of Ellet's supposed sea, since its surface was nearly 300 feet below the rock *in situ*.

But this, according to Ellet, is only 'a has been;' it is exceptional, because this part of the alluvial valley was formed in the sea, which it was not. The bed of the river no longer rises; therefore the river once embanked is always embanked. This is a frightful mistake. The causes which *scooped* the valley of the Mississippi *out* and also *filled* it *in*, are still producing *both* these effects now as actively, nay, *more* actively, than ever. And as long as the river floods, and wherever it floods, it will deposit and raise its banks, and with them its bed. Even the present beds of the mouths of the delta will hereafter be raised as the delta progresses out to sea. As long as the end of the delta remains stationary the depth of the mouths must be stationary to this extent, there must be sufficient depth to let the water into the sea. But as the delta progresses forward into the sea the beds of the present mouths may rise, as the whole bed behind them *does* rise now, and *may*

rise till the alluvial plain reaches the foot of the Rocky Mountains.

Why alluvial rivers receive tributaries without increase of width.

Ellet notices, as an *anomaly* and a peculiarity of the Mississippi, that it receives vast tributaries without an apparent increase of *width*. But can that be called an *anomaly* which is a *law* in all alluvial plains? The cause I have endeavoured to explain in the second edition of the 'Tree-lifter.' Not only are the beds in unalluvial parts inclined, but the land inclines towards the banks. As floods then cannot overflow, they must tear the banks down till they contain the largest possible flood of the river and each tributary; and the channels of unalluvial rivers always are adapted to the *flood-water*, and unduly large for their *spring-water*. But floods in alluvial rivers, instead of *tearing down*, *build up* the banks, and although they cannot build higher than themselves, each year's building increases next year's ponding, and so, *without scaffolding*, they may build infinitely higher than the floods of former years; and this yearly increasing ponding not only raises the deposits *on* the alluvial plain, but *up* the unalluvial plain. The banks of an alluvial river being then high enough to accommodate the *flood-water* till it only just overflows, it is evident that the *spring-water* of each tributary, though it will increase the volume, will not increase the width of an alluvial river. The flood-water of tributaries is not contained at all, but overflows, and so increases the building of the height of the banks. If man pre-

vents the overflow of an alluvial river, he must consider it as an unalluvial river. He cannot, indeed, increase the width between the natural banks, but he may the width between the artificial banks.

Cause of the shape of deltas.

There seems to be a reason in nature for the shape (Δ) of all deltas. For the centre stream or streams, however they may vary their courses, besides causing the delta to bow *out* in the middle towards the sea, also cause it to bow *up* in the middle, along their courses. For all deposits from *moving* water *must* die off in the direction in which the water moves. And in this case the deposits have a *lateral* slope from the river five or six times as great as their longitudinal slope, from ponding. Thus the water does not return over the *general* surface traversed, as it left the river, and so denude the banks which it has deposited. In the alluvial plain the flood-water returns to the main river by *particular* longitudinal channels parallel to the river, which it re-enters below, or by particular lateral channels cut down to the level of the spring-water. But in the delta the flood-water after depositing its load does *not* return to the main river; it escapes to *the nearest points* of the sea, along the two low outsides of the delta. So that the two outside streams with the line of the sea shore form a triangle or delta.

In the last century a French nobleman made a bet that he would get an English horse to do twenty miles in one hour. The *savans* in Paris clearly

proved that this was impossible, on account of the resistance of the atmosphere. Gimcrack was, however, imported to France from England. And Dr. Johnson, in giving an account of the affair, concludes thus, 'Gimcrack, being no philosopher, set to work and did it.'

Dii facientes adjuvant, the English for which is 'try.' And if the United States set to work nationally to embank the Mississippi, whatever human skill and energy can do will be effected by that great nation, but not the less for knowing the true principles of the formation of alluvial plains. If you have a powerful enemy to contend with, you may as well know his real force and his mode of attack, and what his supplies are, and also what your own weak points are.

And in endeavouring to point out that the *natural* causes at work in the valley of the Mississippi against Ellet's magnificent schemes are greater than his estimation of them, it is not meant to argue against those schemes in particular, or against the object of those schemes in general. In Holland those who have perished by floods are numbered by *hundreds* of *thousands*. But since those who have there enjoyed exquisite existences are numbered by *thousands* of *millions*, would any one advocate the desertion by man of the delta of the Rhine? If so, we must desert all those parts of the globe which are richest in the accumulation of soil, therefore in vegetable

existence, therefore in animal existence, and therefore in human subsistence and consequently existence.

> Liberal, not selfish, is kind Nature's hand,
> Nor was perfection made for man below;
> Yet all her schemes with nicest art are planned,
> Good counteracting ill, and gladness woe.

Nihil est ab omni parte beatum. Is life anywhere without risk of death? Are plague, pestilence and famine, empty words? Are battle, murder, and sudden death mere bugbears to scare the timid? Has vegetation no blight? flesh no epidemic? But man takes 'the bite with the buffet.' Earthquakes expel him not from his cities, nor liquid lava from his fruitful fields. Tempests sweep him not from the surface of the ocean, nor fire-damp from the bowels of the earth. But of all the baits at which hungry man rises, none hooks him to such a certainty as the fat valley. From its rank, rich rottenness springs the abundance which gives man ease and time to civilise himself.

The first improvement on the man who fed on acorns and *game* was the *isolated* herdsman, who roamed over vast tracts of hill, or plains of poor soil. The rich valleys were thick forests and jungles. In those days, parvum vacabat liberalibus studiis. But when the agriculturist cleared alluvial plains, man became at once condensed and civilised.

The Paradise for man is formed by

Witness, in the *Old* World, China, India, Chaldæa and Egypt. On the wings of steam modern com-

merce and colonisation call forth and interchange the glorious products of every valley of *the two* worlds, uniting all by *mutual* benefit.* We shall not be stopped out of this by an inundation or two. No, nor by anything short of an angel with a fiery sword. On this globe the paradise for man is that alluvial one prepared for him by

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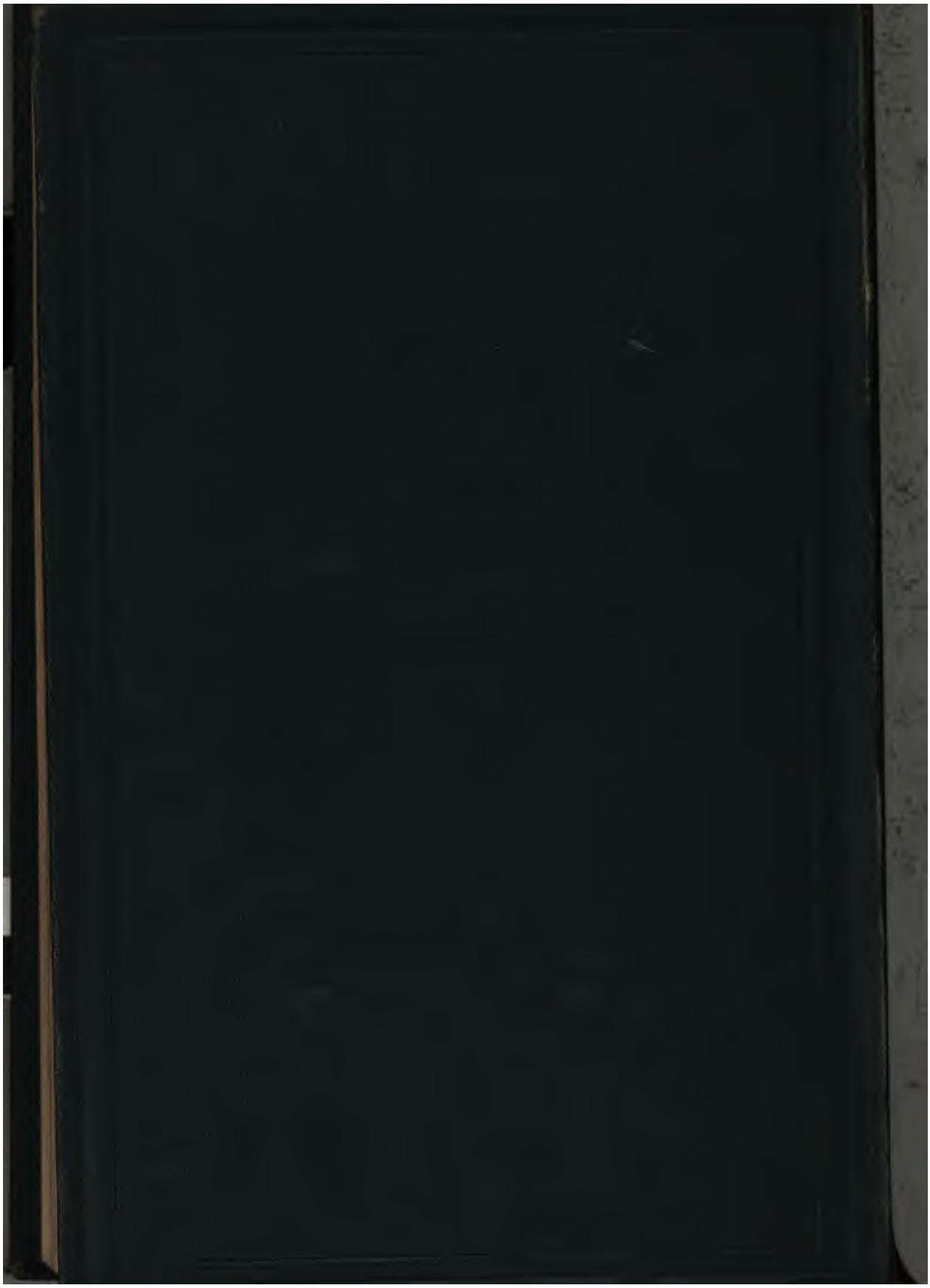
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